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APPLIED MECHANICS REVIEWS

VOL. 7, NO. 6 **MARTIN GOLAND** *Editor* JUNE 1954

BRIEF SURVEY OF RECENT DEVELOPMENTS IN HEAT TRANSFER

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THE past ten years have witnessed many new developments in the field of heat transfer. The engineering developments which perhaps have had the most significant influence on the direction of these heat-transfer activities are the problems associated with the nuclear power plants, jet engines, and gas turbines. The following is a brief survey of some of the results of heat-transfer investigations during the past ten years. No attempt at complete coverage nor complete referencing will be made. A few of the more unusual problems will be discussed and reference made to articles which tend to summarize phases of the work.

BOILING

Heat transfer from a hot surface to boiling liquids has been studied for the case in which the surface, such as a wire or tube, is immersed in a large bath of liquid at the saturation temperature (pool boiling) and for the case in which the fluid flows by forced convection—such as inside a tube, between parallel plates, or in an annulus—both for the condition when the liquid is at the saturation temperature and when it is below this temperature (subcooled). When boiling takes place, heat-transfer rates are far in excess of those occurring for similar temperature differences without boiling. Most of the heat (> 95 per cent) is transferred directly from the wall to the liquid; the bubbles seem to act as agitators of the liquid. Not much is known about the process of nucleation (bubble formation). In the absence of adsorbed gases it seems to be related, however, to the wettability of the surface by the liquid. Also, not much is known about the mechanics of bubble motion. Both of these problems are currently being investigated.

It has been found possible to correlate pool-boiling data for a given surface-liquid combination by employing the concept of a bubble-motion Reynolds-type modulus along with a bubble Nusselt modulus and the liquid Prandtl modulus, resulting in another new dimensionless group which is the ratio of liquid superheat enthalpy at the surface temperature to the latent heat enthalpy. This type of correlation has been successful for various surface-liquid combinations when the surfaces are kept clean and free of adsorbed gas. It has also been found that in forced-convection boiling the heat-transfer process seems to be a superposition of the heat transfer due to boiling as correlated by the previously mentioned method, and the heat transfer due to forced-convection flow as correlated by the ordinary forced-convection correlation such as the Colburn-type equation. This work is summarized in (1).[1]

An analysis leading to a correlation of heat-transfer data in the stable film boiling range in pool boiling has been made, based on the natural-convection flow of the vapor in the stable film in laminar flow. This is summarized in (2).

CONDENSATION

Analyses of the heat-transfer processes associated with condensation on flat plates and round tubes with laminar liquid films, allowing for the effect of vapor velocity and for the effect of the presence of noncondensable gases, are summarized in (3) and (4). Recently, efforts have been directed toward condensation in liquid film flowing in turbulent flow. This work is summarized in (5). If the condensate forms in droplets instead of in a continuous film, the heat-transfer rates are increased tremendously—2 to 10-fold. Not much is known about the mechanism or data correlation of dropwise condensation. Some information on this subject is summarized in (3), (6), and (7).

FORCED-CONVECTION TURBULENT FLOW

The problem of heat transfer to a turbulently flowing liquid has not lent itself to the type of analytical treatment given the laminar flow case (3) because so little is known about the mechanics of turbulence. This case, however, has been investigated with some degree of success by comparing the heat-transfer process with the momentum-transfer process by analogy. This type of analysis has been refined from the original postulate of a tube with a turbulently flowing fluid completely filling the pipe (1875) to the recent studies which postulate regions near the wall in which laminar flow becomes more predominant as the wall is approached. In these recent analyses, transfers by the mecha-

[1] Numbers in parentheses indicate References at end of paper.

nisms of both molecular motion and eddy motion are considered. Some attempts have been made to obtain solutions from a postulate of an analogy between heat transfer and vorticity transfer. These general types of analysis by analogy have been relatively successful in predicting and correlating heat-transfer data for turbulently flowing liquid metals (which, in general, have very low values of the Prandtl modulus) as well as ordinary liquids and gases of higher Prandtl modulus. These results are summarized in (8) and (9).

The same general type of analysis has been extended to problems in which the effect of variable properties is significant—such as in heat transfer from high-temperature gases to the walls of combustion chambers, and heat transfer to fluids at pressures greater than critical. In each of these cases, the properties of the fluids change greatly in a few hundreths of an inch from the wall. These analyses are summarized in (9), (10), and (11).

Most of the previously mentioned analyses are for the cases in which there is either a uniform wall temperature or a uniform heat-transfer rate at the wall along the flow length. An analysis for the case in which there is an arbitrary wall temperature distribution is presented in (12).

CONVECTIVE HEAT TRANSFER AT HIGH VELOCITIES

At high speeds—high subsonic and supersonic flow—the frictional effect in the boundary region produces temperature gradients even in adiabatic flow. It has been observed that the temperature difference "driving force" for the heat transfer should be an adiabatic wall temperature minus the wall temperature. Here the adiabatic wall temperature is a property of the flowing stream and the flow geometry. There is introduced a term called a recovery factor which is defined as the ratio of the difference between adiabatic wall temperature and stream static temperature to the difference between total and static stream temperatures.

Experimental and analytical efforts are directed toward determining and correlating values of recovery factors and heat-transfer coefficients. It has been found by analysis and checked fairly well by experiment that the recovery factor in laminar flow equals the square root of the Prandtl modulus, and in turbulent flow the cube root of the Prandtl modulus. This information is summarized in (13) and (14).

HEAT TRANSFER TO RAREFIED GASES

A rarefied gas is one in which the molecular mean free path is not negligible compared with some characteristic linear dimension of the flow field. Such is the case for missiles in the upper atmosphere. If the mean free path is much larger than a typical body dimension, the body has no appreciably disturbing effect on the incident flow. This region is called the region of free-molecule flow and occurs when the ratio of Mach number M to Reynolds Re is greater than 10.

When the mean free path is less than a typical body dimension but not negligible, the region is called the slip flow region because the gas immediately adjacent to the solid surface may possess a nonzero tangential velocity coefficient, and if a temperature gradient exists in the gas the temperature immediately adjacent to the wall may not equal the wall temperature. This is called a temperature jump.

The analyses of these processes are based on the kinetic theory of gases and are directed toward discovering the important and significant physical phenomena and determining the heat-transfer characteristics and aerodynamic force distributions for specific systems. A review of the available experimental and analytical results is presented in (15).

NATURAL CONVECTION

Heat transfer associated with natural convection has recently been studied under conditions of large body forces such as might be obtained as a result of high centrifugal force fields. The frictional effects and the effect of compression of the gases during the process may appreciably affect this type of heat transfer, introducing into correlations a new parameter involving the body force (16). Recent results of experimental data for liquids and nonmetals to horizontal cylinders were compared with many of the available correlations (17).

RADIATION

Problems associated with cooling of jet engine and rocket combustion chambers have led to many measurements of emissivities of gases and flames. Much of this work will be summarized by Hottel in the 3rd edition of McAdams (6) to be published in mid-1954. Hottel has also developed a new method for analyzing radiation in enclosures such as furnaces. This will appear in the same reference.

CONCLUSION

This survey has presented a few of the many interesting heat-transfer problems currently being investigated. In the interest of brevity, reference to much other important work has been omitted—such as development of new type of heat-exchanger surfaces, measuring techniques, turbine-blade cooling methods, and many others. A more detailed review of activity in the field of heat transfer is found in a collection review paper published by the Industrial and Engineering Chemistry magazine in an early issue each year.

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CHAPMAN, S., and COWLING, T. G., The mathematical theory of non-uniform gases, 2nd ed.—Notes added in 1951, New York, Cambridge Univ. Press, 1953, xxiii + 431 pp.; 40 pp. $10.50; $1.

DOUGHTIE, V. L., and JAMES, W. H., Elements of mechanism, New York, John Wiley & Sons, Inc.; London, Chapman & Hall Ltd., 1954, viii + 494 pp. $6.

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FAXÉN, O. H., Ångtabeller. Thermodynamic tables in the metric system for water and steam, Stockholm, Nordisk Rotogravyrs monografiserie/Hafte 2, 1953 (International ed. of Forskning och teknik 2), 147 pp. 19 Sw. Cr.

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GÖHRE, E., Leistungssteigerung und Ausschussminderung in der Stanzerei, München, Carl Hanser Verlag, 1953, 136 pp., 154 figs., 66 tables. DM 13.50.

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VENNARD, J. K., Elementary fluid mechanics, 3rd. ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall Ltd., 1954, xii + 401 pp. $5.50.

Letters to the Editor

Concerning receptances in mechanical systems:

We wish to propose that the word "receptance" should be used instead of "admittance" as applied to mechanical systems [see AMR **2**, Rev. 567]. By this we mean that, if a generalized disturbing force $F_s e^{i\omega t}$ is applied at the sth generalized coordinate q_s of a linear oscillatory system, then the response at the rth generalized coordinate is given by $q_r = \alpha_{rs} F_s e^{i\omega t}$, where α_{rs} is the "cross receptance" between q_r and q_s. If $r = s$, then α_{rs} would be the "direct receptance" at q_s.

The reason for proposing this change is that there is a possibility of confusion between "admittances" as applied to mechanical and electrical systems. The two uses of the word have related, but not identical, origins.

Comments on this proposal would be appreciated and should be addressed to R. E. D. Bishop, Engineering Laboratory, University of Cambridge, Trumpington Street, Cambridge, England.

W. J. Duncan, Scotland
M. A. Biot, USA
D. C. Johnson, England
R. E. D. Bishop, England

1689. Re AMR 7, Rev. 512 (February 1954): M. M. Krushchov and M. A. Babichev, Resistance to abrasive wear and the hardness of metals (in Russian).

Mr. P. Grodzinski, England, has pointed out that a short English translation of the above article is available through The Joint London Secretaries, St. Andrew's House, 32–34 Holborn Viaduct, London, E.C.1, England, and that a complete translation is available through the Library of Congress, Washington 25, D. C.

1690. Re AMR 7, Rev. 528 (February 1954): E. Becker, Analogies between surges and shock waves.

In the first paragraph of the above review, line 5, the words "different dimensional conditions" should read "different thermodynamic conditions."

In the second paragraph, line 18, the word "supposed" should be "superposed."

The editors regret these typographical errors.

1691. Re AMR 7, Rev. 537 (February 1954): N. Tetervin, Study of stability of the incompressible laminar boundary layer on infinite wedges.

The first paragraph of the review should read:

Using Schlichting's approximate method, Tetervin and Levine [AMR **7**, Rev. 558] calculated for a laminar boundary layer in a region of decreasing pressure that a thick velocity profile can be more stable than a thin profile, although the velocity at the edge of the boundary layer and the pressure gradient are the same in both cases. The present author shows that Hartree's numerical solutions of the boundary-layer equations for the flow over infinite wedges confirm this result. The wedge flows, however, satisfy a basic assumption of the Schlichting method that the velocity profile is a single-valued function of the local effective pressure gradient, and so provide only a partial verification of the result. A. R. Mitchell, Scotland

Theoretical and Experimental Methods

(See also Revs. 1714, 1724, 1728, 1750, 1770, 1843, 1867, 1911, 1932, 1952, 2007)

1692. **Duncan, W. J., Physical similarity and dimensional analysis,** London, Edward Arnold & Co.; New York, St. Martin's Press, 1953, vii + 156 pp. $6.

This book supplies a valuable source for the application of dimensional analysis to the theory of physical similarity. Some of the subjects covered are: (1) Units and measures; (2) Geometric and kinematic similarity; (3) Similarity in Newtonian dynamics; (4) Fluid motion; (5) Heat; (6) Electromagnetism; (7) The use of nondimensional coefficients in design.

Author is to be commended on the clarity with which the book is written. Reviewer found the discussion on the physical dimensions of differential coefficients and of integrals to be of especial interest. This book is a definite contribution in its field.

C. B. Matthews, USA

1693. **Solaja, V., The application of dimensional analysis in static deformation** (in Serbian), Annual of the Mechanical Engineering Faculty, Belgrade, 1953, 95–99.

The method is used to find the equation of the force necessary to plastically deform a solid body. By applying a proposal by Zscheile, the equation is received in the form $F = c.d^{n_1}.h^{n_2}.t^{n_3}$. The values of the coefficient c and the exponents n_1, n_2, and n_3 are tabulated for the various intervals of temperature and ratios of diameter/height. The discussion of the exponents provides information on the influence of the dimensions of the body.

From author's summary by A. O. Schmidt, USA

1694. **Berger, E. R., Variational principles for the solution of the plate equation** (in German), *Öst. Ing.-Arch.* **7**, 1, 39–49, 1953.

Let w^* be the real deflections of a plate having any given loads in the field and on the S' portion of the boundary, and submitted to prescribed constraints (deflections, slopes) on the S portion.

Using the Ritz method, the preliminary functions of the approximating series must satisfy the marginal conditions ($w = \bar{w}$) on S, and the coefficients are determined (principle of least work) by bringing to a minimum the total energy Π (sum of strain energy and potential energy of loads).

If, instead, the chosen functions are completely arbitrary, a second variational principle, derived from Trefftz's procedure, is suggested by author: function $\Pi' = \Pi - {}_s\int R(w)[w - \bar{w}]ds$ is such as to give $\delta\Pi' = 0$ for the real solution, $R(w)$ being the reactive forces on S in the solution w.

Besides, if the preliminary functions satisfy the equilibrium equations both in the field and on S' (marginal conditions not fulfilled on S), Π' reaches a maximum for $w \rightarrow w^*$.

When two approximate solutions are obtained from the two principles, the difference $\Pi_{\min} - \Pi'_{\max}$ may measure the degree of approximation.

Proposed method does not require the choice of arbitrary weights in order to render the different functions (deflections, slopes, moments, forces) homogeneous; this is an advantage over the method of minimizing the integral of error-squares on the boundary.

D. Gentiloni-Silverj, Italy

1695. **Lesky, P., On a special class of second boundary-value problems** (in German), *Öst. Ing.-Arch.* **7**, 3, 231–236, 1953.

Fourier analysis is used to obtain explicit forms for a harmonic function whose normal derivative takes alternately positive and negative boundary values in the four quadrants of a circular or elliptic region. No applications are given. B. R. Seth, India

1696. **Babukov, A. G., A boundary-value problem for the telegraphist's equation,** Nat. Sci. Found. tr-40, July 1953; *Doklady Akad. Nauk SSSR (N.S.)* **88**, 4, 635–637, Feb. 1953.

The problem studied in this paper occurs in the theory of depth pumps. Several other problems in the theory of longitudinal oscillations of rods and in electrical engineering can be reduced to this problem.

From author's summary

1697. **Unger, H., A technique for biorthogonalizing eigenvectors and principal vectors** (in German), *ZAMM* **33**, 10/11, 319–331, Oct./Nov. 1953.

When a nonsymmetric matrix A of order N has multiple eigenvalues, e.g., $\lambda_i = \ldots = \lambda_{i+m}$, it may (though need not) happen that it has fewer than N eigenvectors. In such a case one may complete the space spanned by the eigenvectors to an N-dimensional space by adjoining the independent solutions of $(A - \lambda_i)^r X = 0$, $r = 2, 3, \ldots$ to those of case $r = 1$. The so-determined vectors are called principal vectors; together with the eigenvectors they span the N-dimensional space. They may be orthonormalized with respect to the eigenvectors and principal vectors of the transposed conjugate matrix A'. This biorthogonalization process is carried out in the paper, utilizing a modified Gaussian algorithm in conjunction with a generalized Gram matrix.

G. Horvay, USA

1698. **Zubov, V. I., Some sufficient criteria for stability of a nonlinear system of differential equations** (in Russian), *Prikl. Mat. Mekh.* **17**, 4, 506–508, July-Aug. 1953.

Consider the n-vector, $n \times n$ matrix system $\dot{x} = A(x; t)x$ and set $G = \frac{1}{2}(A + A')$. Let $\lambda_i(x; t)$ be the characteristic roots of B. Theorem 1: If the $\lambda_i \leqq 0$, the origin is stable. The proof rests upon the immediate relation in which x is considered as a column vector: $\frac{1}{2}d(x' \cdot x)/dt = x'Bx$. An orthogonal transformation is applied normalizing B. In the new unknowns z_i, one finds (Euclidean norm)

$$||z(t)||^2 = ||z(t_0)||^2 \exp 2 \int_{t_0}^{t} \frac{\Sigma\lambda_i z_i^2(t)}{||z(t)||^2}\, dt$$

leading at once to the theorem. Noteworthy consequences: (1) If $\lambda_i < -\delta < 0$, then the origin is asymptotically stable. (2) A need not satisfy the conditions for the uniqueness of solutions. Under the circumstances a trajectory may reach the origin in finite time, but under the conditions of the theorem it will not be able to leave the origin. (3) Consider a system $\dot{x} = X(x; t)$, where $X(0; t) = 0$. Let $J = (\partial X_n/\partial x_i)$. If the characteristic roots of $\frac{1}{2}(J + J')$ are $\leqq 0$, the origin is asymptotically stable. (4) Let $\lambda(t) \geqq \lambda_i(x; t)$ [$\leqq \lambda_i(x; t)$] for $t_0 \leqq t < +\infty$. If ${}_{t_0}\int^t \lambda(t)dt < +\infty$ [$= +\infty$], then the origin is stable [unstable].

Let $A(0; \infty) = C$, a constant matrix, and let $\nu_1, \ldots, \nu_n$ be the characteristic roots of C. Theorem 2: If $A(0; \infty)$ is continuous at $x = 0$, $t \rightarrow +\infty$, and if the ν_i all have negative real parts, then the origin is asymptotically stable. Noteworthy consequence: Take again $\dot{x} = X(x; t)$ as before. If the characteristic roots $f_i(x; t)$ of J are such that the $\rho_i(0; \infty)$ have negative real parts, then the origin is asymptotically stable for the system.

S. Lefschetz, USA

1699. **Samelson, K., and Bauer, F. L., Optimal computation accuracy for digital computers with floating decimal points** (in German), *ZAMP* **4**, 4, 312–316, 1953.

A logical design is presented for carrying out arithmetic operations in digital automatic computers with floating binary point. It differs from customary schemes in that the significant digits of a number are stored in the least significant positions of the space

available for storage; e.g., 123.45 is stored as 0.00000 12345 $\times$ 10^8 rather than 0.12345 00000 $\times$ 10^3. This prevents the deceptive appearance of nonsignificant figures inherent in the older schemes. The detailed steps occurring in the four arithemtic operations and in conversion between decimal and binary number representation are described. The authors point out correctly that the automatic control of the magnitude of rounding errors, which is the principal feature of this scheme, applies only to single arithmetic operations, and that the growth of these errors through propagation in the course of a series of operations is not prevented or estimated.

F. L. Alt, USA

1700. **Thomas, E. L., A new electronic analogue computor. A compact general-purpose instrument designed for quantity production,** *Aircr. Engng.* **25,** 297, 349–353, Nov. 1953.

1701. **Van Haver, V., Solving acoustical problems by means of electrical models** (in Dutch), *Tech. Wet. Tijdschr.* **22,** 7, 141–150, July 1953.

The author points to the analogy between acoustical and electromagnetic phenomena. This covers wave structure, a few practical cases of which are described, as well as wave propagation.

From author's summary

1702. **Green, H. S., and Messel, H., On the expansion of functions in terms of their moments,** *Quart. appl. Math.* **11,** 4, 403–409, Jan. 1954.

A method is devised for the reconstruction of functions of a continuous variable from their moments. An analog is given for functions of a discrete variable. An application is given to the solution of partial differential equations with a given initial condition.

From authors' summary by H. G. Loos, USA

1703. **Birkhoff, G., Young, D. M., and Zarantonello, E. H., Numerical methods in conformal mapping,** "Fluid Dynamics," Proc. Symp. appl. Math., vol. IV; New York, McGraw-Hill Book Co., Inc., 117–140, 1953.

Authors review existing methods for computing conformal transformation that maps the exterior (or interior) of a general smooth closed curve C onto that of a circle and also those for free boundary problems involving simply connected flows. These are essentially processes of reducing to appropriate integral equations by complex variable theory, and then solving by discretization and iteration. Based on a comparison of relative accuracy and rate of convergence for a 3:2 ellipse, it is concluded that for fixed boundary problems, Theodorsen's method, Gerschgorin's method, and a method by the authors are all equally efficient, although the first one is quicker while the two latter ones are usually more accurate. For regions more nearly circular, a modified Theodorsen method is suggested, while for less "nearly circular" regions, both the method by the authors and a modified Gerschgorin method are recommended. For free boundary problems, a method developed in line with Levi-Cività's work is introduced. Other methods involving either iteration, parametrization, or noniterative orthogonalization are briefly discussed. Integral equation of Villat is also mentioned.

H. S. Tan, USA

1704. **Eltermann, H., Numerical integration with nonequal increments of the abscissa; calculations of line integrals** (in German), *ZAMM* **33,** 254–255, 8/9, Aug./Sept. 1953.

For numerical integration of $f(x)$, given in $x = x_\nu$, $\nu = 0, 1, \ldots, n$, often auxiliary functions $\varphi_\nu[\varphi_\nu(x_\mu) = \partial_\nu{}^\mu]$ are introduced, and $f(x)$ is replaced by $\Sigma f_\nu \varphi_\nu$, $f_\nu = f(x_\iota)$. The integral will then be approximated by $\Sigma f_\nu g_\nu$ where $g_\nu = {}_{x_0}\int^{x_n} \varphi_\nu(x)dx$. In general, the g_ν are not linear in the x_ν. A simple device is given here, namely introduction of a new variable of integration, to obtain linear formulas for the weights. The procedure is well suited for the evaluation of line integrals.

A. van Heemert, Netherlands

1705. **Wilson, W. A., Design of power-plant tests to insure reliability of results,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-156, 6 pp.

The title of this paper is somewhat misleading as it is concerned primarily with the application of the uncertainty analysis of Kline and McClintock to the determination of errors in any test procedure. The discussion is presented in the form of a cook-book procedure and should prove useful to those concerned with tests and testing.

The method given does not relieve the user of the necessity for carefully estimating the probable and possible errors in the individual measurements, but does enable the effect on the overall test results to be predicted and, as the author states, will indicate in which respects the test is overdesigned and in which respects the design is inadequate.

As he further concludes, "The successful and economic application of this formula depends heavily upon a background of experience and the capacity to distinguish important from trivial decisions. Conscious application of this method will accelerate the development of judgment relative to test procedures."

A. O. White, USA

1706. **Saltz, M. H., Practical uses of statistical quality control,** *Tool Engr.* **32,** 2, 49–52, Feb. 1954.

⊗1707. **Bickley, W. G., Bessel functions and formulae,** New York, Cambridge University Press, 1954, 40 pp. \$0.75.

This is extracted from British Association Mathematical Tables vol. X, Bessel Functions, part II, Functions of Positive Integer Order. It is a useful compendium, giving in compact form an extensive list of formulas including recurrence formulas, series and integral representations, asymptotic expansions, auxiliary functions, etc.

Y. Luke, USA

⊗1708. **Tables of circular and hyperbolic sines and cosines for radian arguments,** U. S. Dept. Comm., Nat. Bur. Stands. appl. Math. Ser. 36, x + 407 pp. \$3.

In this third edition, all errors reported in former editions have been corrected. Principal table of items in title to 9d for x = 0(.0001)1.9999 is same for all editions. Present edition extends a supplementary table for conversion of degrees to radians, etc., and includes a table of multiples of $\pi/2$.

Y. Luke, USA

Mechanics (Dynamics, Statics, Kinematics)

⊗1709. **Chazy, J., Course in rational mechanics. I. 4th rev. ed. [Cours de mécanique rationnelle. T. I],** Paris, Gauthier-Villars, 1952, 510 pp.

This text, whose first volume consists of dynamics of a particle, reproduces author's lectures given at the University of Paris during the period 1928–1941. The general treatment is in the classic French tradition for presenting texts on rational mechanics. The text is essentially a mathematical treatment with special attention devoted to qualitative results obtained in the light of elementary existence theorems and to a discussion of singularities of motion when these theorems fail to apply. The mode of presentation of the material is clear and rigorous. There

are no illustrative exercises throughout the book. A collection of examination problems in rational mechanics for the years 1928–1951 is appended.

In reviewer's opinion, this text can be highly recommended to mathematicians, physicists, and theoretically minded engineers.

Chapter headings are: I Theory of vectors. II Principles of mechanics. III General theorems on the motion of a particle. IV Rectilinear motion of a particle. V Curvilinear motion of a particle. VI Motion of a particle on a curve. VII Motion of a particle on a surface. VIII Motion relative to the earth.

E. Leimanis, Canada

1710. Shaffer, B. W., and Cochin, I., Synthesis of the quadric chain when the position of two members is prescribed, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-144, 10 pp.

Criterion for determining whether a four-bar linkage is possible for performing function $\gamma = f(\psi)$, where γ is angle of driving link and ψ angle of driven link. From generalized linkage form, compatibility equation is developed relating γ to ψ. If a required function $y = g(x)$ satisfies compatibility equation, then a four-bar linkage is possible, and if so, the ratio of link lengths is obtainable. If the compatibility equation is satisfied only for a finite range of real values, γ is restricted to lie between certain angular limits at which mechanism locks. Reviewer believes paper has theoretical significance in quantitatively evaluating possibilities for use of four-bar linkage to reproduce a given function $y = g(x)$.

L. R. Koenig, USA

1711. Mack, C., Theoretical study of ring and cap spinning balloon curves (with and without air drag), *J. Text. Inst. Trans.* **44,** 11, 1183–1198, Nov. 1953.

1712. Bialkowski, L. S., The basic problem of undercarriage geometry, *Aircr. Engng.* **25,** 294, 236–238, Aug. 1953.

The landing position and the retracted position of the wheel axis of the landing gear are given. These axes need not intersect nor be parallel. The problem of the determination of the axis of rotation to carry one position into the other is considered. This axis of rotation must lie in the plane which is the perpendicular bisector of the line joining corresponding points. If two distinct points are taken, the intersection of their corresponding planes gives the desired axis of rotation. The solution is presented here by detailed conventional descriptive geometry drawings.

M. Goldberg, USA

1713. Blanton, H. E., Use of flight simulators in the design of aircraft control systems, *Aero. Engng. Rev.* **13,** 2, 29–35, Feb. 1954.

During recent years the use of analog computers in the design of aircraft control systems has increased. Specialized flight simulators, computational facilities capable of solving the equations of flight in conjunction with realistic laboratory testing of actual control-system components, have been developed. Often a simulator includes a flight table for subjecting the required components to the angular motions that would be experienced in flight. On the basis of a review of the mathematical problems associated with guided flight and of the capabilities of existing simulators, the way in which a simulator may be used most effectively in an aircraft development program can be outlined. The relative value of a flight table during such a program has not been established fully; however, laboratory "test flights," with the control-system components incorporated in the simulator, frequently may verify previous calculations based on measured or predicted characteristics and insure successful system performance during actual flights.

From author's summary

1714. Sahmel, P., Determination of centrifugal force acting upon complicated shaped bodies by aid of a nomogram (in German), *ZVDI* **95,** 31, p. 1060, Nov. 1953.

Author describes graphical determination of polar moment of inertia of irregular lamina which is required for evaluation of centrifugal force. Thus polar moment of inertia of F about O is proportional to area of F' where point P' on periphery of F' corresponding to P on F is obtained by producing PO to P' so that $OP'^2 = (2/3)OP^3$. This can be effected by use of a specially scaled polar rule. Method is applicable to evaluation of centrifugal force on governor weights and on impeller blades of rotary pumps.

Method can easily be extended to evaluation of higher moments. Reviewer notes that method is advantageous when an Amsler-type integrator is not available.

S. Kirkby, England

Servomechanisms, Governors, Gyroscopics

(See also Revs. 1713, 1854)

1715. Bower, J. L., and Tuteur, F. B., Dynamic operation of a force-compensated hydraulic throttling valve, *Trans. ASME* 75, 7, 1395–1406, Oct. 1953.

Paper is a study of the dynamics of hydraulic throttling valves compensated for hydraulic reaction forces. Force compensation achieved through the use of restrictions in the valve is employed as a means of eliminating one type of valve instability. A transfer function valid for small input amplitudes is developed which includes these hydraulic reaction forces. In the development of the transfer function, flow and force functions are assumed to be empirical and are determined by actual measurement. This would limit the usefulness of the transfer function in synthesis of hydraulic servos. Authors indicate how the analysis may be extended and the restriction on small input amplitudes removed through the use of an analog computer.

See AMR 6, Rev. 527, for another treatment of the problem of instability of hydraulic throttling valves and a different means of providing force compensaion. Also see AMR 6, Rev. 731, for another treatment of the dynamics of four-way valve servos (hydraulic reaction forces in valve not considered).

S. Z. Dushkes, USA

1716. Ceaglske, N. H., and Eckman, D. P., Automatic control of a pressure process, *Indust. Engng. Chem.* **45,** 9, 1879–1885, Sept. 1953.

A simple gas-pressure process, characterized by second-order control equation, is subjected to frequency response analysis.

System parameters are found experimentally, using both transient and frequency-response methods, and controller gain is determined for various load conditions and set points to yield arbitrarily specified "satisfactory" transient response. Although control equations are sufficiently simple to be solved outright for transient response, purpose of paper is apparently to persuade process engineer to use frequency-response method for more complicated process controls.

L. Becker, USA

1717. Arneodo, C., Study of the dynamical behavior of boilers with the Philbrick electronic calculating machines (in Italian), *Termotecnica* **9,** 9, 389–395, Sept. 1953.

A qualitative solution of the dynamic characteristics of a boiler is obtained using an electronic analog computer. Author considers small variations of boiler properties with respect to time, linearizing the differential equations describing the dynamic fluctuations of boiler properties. The boiler has an automatic feed mechanism controlled by the steam pressure. The general

form of the linear differential equation describing the variations of boiler properties is taken as $x = y + T(dy/dt)$, where T is the time constant of the system that relates the two properties x and y. Stability conditions are described and oscilloscope traces are shown for various choices of time constants. S. Eskinazi, USA

1718. **Webb, C. R., and Ozanne, D. J., A frequency response analyzer for pneumatic process control systems,** *J. sci. Instrum.* 30, 11, 424–426, Nov. 1953.

A simple and relatively inexpensive instrument is described for use in harmonic response tests on closed-loop process control systems. It is capable of a high degree of accuracy in the measurement of amplitude ratio and phase difference.

From authors' summary

1719. **Levy, S., and Kroll, W. D., Errors introduced by finite space and time increments in dynamic response computation,** *J. Res. nat. Bur. Stands.* 51, 1, 57–68, July 1953.

See AMR 6, Rev. 2446.

Vibrations, Balancing

(See also Rev. 1852)

1720. **van Santen, G. W., Introduction to a study of mechanical vibration,** Eindhoven, Philips' Technical Library; Houston, Elsevier Press, Inc., 1953, xvi + 294 pp.

This book gives a highly readable exposition of the entire field of vibration. In the main it covers material which is usual in books intended for mechanical engineers, but, in addition, other topics are included, of which may be mentioned the Firestone electromechanical analogy, theories of internal damping in materials, acoustics and wave propagation, and the physiology of the ear. In a final chapter, measuring instruments are discussed in much greater detail than is usual in a book of 300 pages covering so wide a field. This last chapter is particularly interesting, although for the general reader it suffers from the fact that almost all instruments described are made by the manufacturer who is the sponsor of this volume and that competitors' products are left unmentioned. There are numerous references to the literature, including many books and papers which are not too familiar here and, hence, can be of interest and use to United States readers. The book is well written and illustrated and gives as good an account of the subject as can be compressed in so small a compass. J. P. Den Hartog, USA

1721. **Eringen, A. C., Transverse impact on beams and plates,** *J. appl. Mech.* 20, 4, 461–468, Dec. 1953.

Flexural deflections of several plates and beams under an unknown transverse, concentrated, time-dependent force are solved for various edge conditions. Consideration of displacements and the use of Hertz' law of impact at the point of contact lead to a nonlinear integral equation for the contact force in all cases of transverse impact. Two methods are introduced to treat this equation: (a) Generalized Galerkin method; (b) collocation method. Method (a) is the generalization of the well-known Galerkin method which is suitable for problems in which part of the boundary is unknown in advance, while certain conditions are given there. The method is applicable to a very large class of differential and integral equations. The collocation method leads to a quick, reasonable, approximate solution. Various auxiliary curves in both cases reduce the solution to a routine. Examples are worked out and plotted for various beams and plates. Deflections are plotted.

From author's summary by F. K. G. Odqvist, Sweden

1722. **Junger, M. C., Dynamic behavior of reinforced cylindrical shells in a vacuum and in a fluid,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-1, 7 pp.

Paper presents an analysis of the vibrations of an infinite cylindrical shell in a vacuum and submerged in a fluid medium. The shell is reinforced by regularly spaced septa and by ring stiffeners. Associated acoustical phenomena are considered. The dynamic equations are obtained by the Lagrange equations. The fluid reaction on the shell is determined from the wave equation which is satisfied by the pressure in the sound field generated by the shell vibration. A remarkable feature of reinforced cylindrical shells is that the inertial component of the fluid reaction becomes very large under certain conditions, thus tending to eliminate some modes of vibration. P. G. Jones, USA

1723. **Brewster, O. C., Simplified analysis of complex vibration problems,** *Prod. Engng.* 24, 11, 161–166, Nov. 1953.

Paper discusses methods of analysis of linear harmonic vibrations, comparing the mobility method with complex vector and differential equation notation. Reviewer believes the subject of second-order differential equations has been exhaustively treated, digested, simplified, and defined in previous papers. The mobility method adds little to these categories, being essentially an impedance notation scheme. J. B. Duke, USA

1724. **Hahn, W., The significance in mechanics of a geometrical difference equation** (in German), *ZAMM* 33, 8/9, 270–272, Aug./Sept. 1953.

A light string has an infinite number of point masses attached to it. The masses and their distances apart, taken in order, are in geometric progression with the same ratio less than unity. The system swings in a gravitational field and the equation of motion for small transverse displacements of the point masses is shown to be equivalent to a geometrical difference equation.

A. R. Mitchell, Scotland

1725. **Okabe, J., On a forced lateral vibration of a number of particles attached to a string at equal intervals,** *Rep. Res. Inst. appl. Mech., Kyushu Univ.* 2, 7, 147–154, Sept. 1953.

Author obtains differential equations for forced vibration of N particles of equal mass and equally spaced on a massless string. The solution for the displacement of any particle is expressed in the form $\phi_n = H(N; n)/G(N)$ where $H(N; n)$ and $G(N)$ are determinants of the Nth order. By use of the theory of determinants $H(N; n)$ is expressed in terms of $G(N)$. The determinant $G(N)$ is then solved by a method developed by the author, the results of which agree with those obtained by the Rayleigh transformation method. P. G. Jones, USA

1726. **Marquard, E., Vibrations of fast street vehicles [Schwingungsdynamik des schnellen Strassenfahrzeugs],** Essen, Verlag W. Girardet, 1952, 228 pp. DM 20.

Contents: General survey of the problem (11 pp.); Determination of basic quantities (center of gravity, spring characteristics, calculations of springs, damping forces, mass moments of inertia) (58 pp.); The simple vibrating system (21 pp.); The simply coupled vibrating system (34 pp.); Natural frequencies and resonance ranges of the vehicle (12 pp.); Riding over obstacles (15 pp.); Landing impact of aircraft (!) (10 pp.); Experimental vibration research (12 pp.); Shimmy (18 pp.); Springs for motion in curves (6 pp.); Roll stability of aircraft (!) and motorcars (17 pp.); Appendix (containing approximate methods for integration) (6 pp.).

Book is written with the expressed purpose of collecting the essential information related to the subject and to offer it in an

easily intelligible form. The author furthermore explicitly professes aiming primarily at rational clarity (p. 14).

Laudable as the aims are, the achievement falls far short of the mark. As to the information offered, the book may serve some useful purpose; it discusses numerous details and points of view and gives some reports on pertinent literature on the subject (although most of them are confined to the German literature). The more severe deficiencies are found in regard to exactness and clarity. The book, particularly in its more general and basic parts, is full of unprecise statements, inconsistent terminology, careless wording, and what seems to be even unclear thinking. Reviewer is prepared to substantiate these critical remarks by a wealth of examples and thus to defend his opinion.

K. Klotter, USA

1727. Okabe, J., On the motion of a trolley-wire, *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **2,** 7, 111–145, Sept. 1953.

Author gives a lengthy mathematical analysis of vertical vibration of a trolley wire which is assumed to consist of a string of negligible rigidity and infinite length. The auxiliary wires which cross the main line perpendicularly at equal intervals are assumed to be equivalent to concentrated masses attached to the wire and equivalent to linear springs. Damping caused by air resistance, internal friction, etc., is assumed to be viscous in nature. Correlation of results of analysis with observed phenomena is not given.

P. G. Jones, USA

1728. Okabe, J., An illustrative example of solving a sum equation by Fourier transforms, *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **2,** 7, 155–160, Sept. 1953.

This note is a by-product of author's calculation of the motion of a trolley wire (see preceding review). Fourier transforms are applied to a difference equation of infinite order. Under assumptions of periodicity for the solutions, series expansions for these are obtained and physical interpretations given. The author observes that some sacrifice of mathematical rigor has been made in order to achieve progress in a highly complex group of problems.

W. M. Whyburn, USA

1729. Lyman, J., A new space rate sensing instrument, *Aero. Engng. Rev.* **12,** 11, 24–30, Nov. 1953.

Paper presents the general principles involved in the operation of the Sperry Gyrotron angular-rate tachometer, a new instrument for measuring angular rate relative to fixed space. The exposition of the operation of the Gyrotron is qualitative. The physical principles underlying the operation of this device are clearly presented and some of the factors essential to the design of a practical instrument are discussed.

L. A. Pipes, USA

1730. Barnaby, R. E., Chatterton, J. B., and Gerring, F. H., General theory and operational characteristics of the Gyrotron angular rate tachometer, *Aero. Engng. Rev.* **12,** 11, 31–36, 106, Nov. 1953.

Paper presents the mathematical theory, the operational characteristics, design details, and applications of the Gyrotron angular-rate tachometer, a new device for measuring angular rate relative to fixed space. This device is a development of the Sperry Gyroscope Company and utilizes a vibrating system composed of two identical masses driven magnetically in opposition in the same plane with equal amplitudes. The principle of the Gyrotron tachometer is analogous to that of the Foucault pendulum, but differs from it in that the vibrating mass is elastically constrained to rotate with the supporting structure. It is pointed out that this new instrument has promising applications for long-term navigation and in applications where ruggedness, fast response, and long life are required.

L. A. Pipes, USA

Wave Motion, Impact

(See also Revs. 1870, 2041, 2042, 2043)

1731. Cole, J. D., Dougherty, C. B., and Huth, J. H., Constant-strain waves in strings, *J. appl. Mech.* **20,** 4, 519–522, Dec. 1953.

Paper discusses the nonlinear problem of waves propagated in strings when a given point is given a constant velocity perpendicular to the string. Using the method of characteristics, it is found that waves are propagated at two speeds, one corresponding to the longitudinal wave and the other a transverse wave dependent on the initial tension and strain, or on the imposed velocity. The results are applicable to large deflections. The case of varying velocity imposed can be obtained by superposition of the constant velocity problem.

W. T. Thomson, USA

1732. Nanninga, N., The problem of pile driving (in Dutch), *Ingenieur* **65,** 42, 207–211, Oct. 1953: Proc. Third Inter. Conf. Soil Mech. Foundation Engng., Aug. 16–27, 1953, vol. II, 71–74.

This theoretical paper deals with the process of transfer of energy from hammer to pile. It is shown that a very good transfer can be effected in principle by using an elongated hammer of constant cross section related to the cross section of the pile. In this way, the following advantages are reached: (a) All the kinetic energy is carried over from hammer to pile; (b) the shock waves have such a length that the stress is constant all along the pile; (c) the stresses are known and depend exclusively upon the height of fall of the hammer; (d) the shock duration and the wave length are directly proportional to the effective length of the hammer.

Ch. Massonnet, Belgium

1733. Travers, S., Temperature at the interface of detonation waves (in French), *C. R. Acad. Sci. Paris* **237,** 23, 1492–1493, Dec. 1953.

Elasticity Theory

(See also Revs. 1766, 1806)

1734. Pister, K. S., The Airy stress function in curvilinear coordinates with application to the uniform flexure of a naturally curved spiral beam, *J. Franklin Inst.* **257,** 1, 25–36, Jan. 1954.

The use of the Airy stress function is extended to isometric curvilinear coordinate system. This is done by conformally mapping the rectangular Cartesian coordinate plane upon the curvilinear coordinate plane. For a given coordinate system, the components of the metric tensor are expressed in terms of the mapping function. As an example, the uniform flexure of a beam whose edges are bounded by logarithmic spirals is discussed. Limiting cases of this example yield the uniform flexure of a wedge acted upon by a moment at the vertex, and the uniform flexure of a sector of a circular ring.

G. V. R. Rao, USA

1735. Goodier, J. N., and Hsu, C. S., Transmission of tension from a bar to a plate, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-41, 4 pp.

The transmission of a force from a beam to a plate, to which the beam is lap-jointed, leads to an integral equation whose numerical results are compared with strain-gage measurements on a monolithic model. The agreement seems to be fair and shows that the transmission depends especially on the detailed local character of the joint where the beam meets the plate.

H. Neuber, Germany

1736. **Feigen, M., A note on Poisson's ratio,** *J. aero. Sci.* **20**, 11, 785, Nov. 1953.

Author considers an isotropic solid under uniform axial stress producing an axial extension ϵ_x per unit length and a lateral contraction ϵ_y, and he defines a Poisson's secant ratio $\nu_S = \epsilon_y/\epsilon_x$ and a Poisson's tangent ratio $\nu_T = \Delta\epsilon_y/\Delta\epsilon_x$, where $\Delta\epsilon_x$, $\Delta\epsilon_y$ are small increments in ϵ_x, ϵ_y corresponding to a given small increment in axial stress. He then derives simple formulas for ν_S, ν_T as a function of the classical Poisson's ratio ν', the Poisson's ratio ν'' for completely plastic deformation, and the ratios E_S/E and E_T/E of secant modulus and tangent modulus to Young's modulus. Application to a specific stress-strain curve with $\nu' = 0.33$, $\nu'' = 0.5$ shows that ν_T approaches ν'' rapidly as ϵ_x is increased beyond the elastic range, while ν_S approaches it very slowly.

W. Ramberg, USA

1737. **Krisch, A., Mathematical equation for the strain-stress curve** (in German), *Arch. Eisenhüttenw.* **24**, 9/10, 401–405, Sept./Oct. 1953.

Author starts from the parabolic equation $\sigma = a\epsilon^n$, which was presumed to describe the relation between true stress and logarithmic strain up to the maximum load in the tension test. He points out that the constants of this equation are computed from the stress and strain at the maximum load, determined by experiment, and that the equation generally does not fit the experiments in the region of the 0.2% yield point. In order to diminish this discrepancy, author developed a mathematical correction factor, which makes it possible to take the experimental value for the 0.2% yield point into account. Thus the theoretical curve is corrected in the region of the yield point only. Reviewer doubts the significance of this purely mathematical treatment, which is not based on any physical concept.

J. H. van der Veen, Holland

1738. **Karunes, B., Stress distribution in an infinite plate with an elliptic hole acted upon by a force and a couple at an internal point,** *Indian J. Phys.* **27**, 9, 439–446, Sept. 1953.

Author uses the complex stress-function method of Muskhelishvili for solving two-dimensional problems in elasticity. He obtains stress functions corresponding to a concentrated force or couple applied at an arbitrary point inside the plate, assuming that the boundary of the hole is free from tractions. When the point of application approaches the boundary of the hole, the results reduce to those given by Rothman [AMR **4**, Rev. 1034] for this special case. For the special case of a force acting along a radius of a circular hole, the results reduce to those given by Sen [*Bull. Calcutta math. Soc.* **37**, p. 37]. R. A. Clark, USA

1739. **Higuchi, M., Orthotropic semi-infinite plate with a hole,** *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **2**, 7, 161–163, Sept. 1953.

An application of the theory in a previous paper [AMR **5**, Rev. 3042] is made for the case of a circular hole in a semi-infinite plate of compreg under uniform tension. M. V. Barton, USA

1740. **Karunes, B., On the distribution of stress round the edge of a hole in a deep beam under a uniform bending moment,** *Indian J. Phys.* **27**, 7, 373–378, July 1953.

Plane stress in an infinite elastic plate containing a hole is investigated. As x becomes infinite, σ_x varies linearly with y and the other stress components vanish. Hence, solution is applicable to pure bending of a deep web that contains a hole. Boundary of hole belongs to a three-parameter system of closed curves. This system includes circular holes, elliptical holes, and holes approximating equilateral triangles and squares with rounded corners, as well as clover-leaf patterns and other complex shapes.

Analysis is based on Green's adaptation of Muskhelishvili's treatment of boundary-value problems of the biharmonic equation by the theory of complex variables.

H. L. Langhaar, USA

1741. **Wegner, U., Two problems of the theory of elasticity** (in German), *ZAMM* **33**, 8/9, 300–303, Aug./Sept. 1953.

The first problem refers to the determination of stresses in a frame of unit thickness subjected to centrifugal force. Stresses at the center are of particular interest. For $1 \geqslant H - h$, the stresses may be determined with sufficient accuracy using the elementary flexural theory, but results obtained in this manner will be inaccurate if the ratio $1/(H - h)$ is not very large. Author uses a variational method to solve the problem, because it is particularly applicable to doubly connected bodies and for stress determinations at points away from the corners. Starting from Airy's function, taken as the sum of two functions, i.e., $F_i = F_h + F_0$, author establishes the boundary conditions for the doubly connected body. Three arbitrary constants appear in these expressions. Making $\Delta F_h = \varphi(xy)$, it follows that $\Delta\varphi = 0$ must be zero and it is then possible to determine φ by means of a variational equation. Author applies his solution to a practical example, comparing the results with those of the elementary theory, and obtains differences from 300 to 400% for compressive and tensile stresses, respectively.

The second problem deals with two rectangular plates of the same material fully in contact along one edge and heated differently. The problem is to find the lengthwise stress distribution. Author supposes the rectangular plate to be a semi-infinite strip $2H$ in width and 2δ thick, and agrees with Marguerre [*Ing. Arch.* **8**, p. 216, 1937] that the temperature change in a thin plate, whose upper and lower faces transfer heat according to Newton's law, is governed by the equation $\Delta T^{(\nu)} = \eta^2(T^{(\nu)} - T_0 + \partial T^{(\nu)}/\partial_t)$ (T_0 = air temp). Furthermore he establishes the temperature conditions at the boundary and the stress function $\Delta\Delta F_i^{(\nu)} = -2(m+1)\,m^{-1}G\alpha\Delta T^{(\nu)}$; $F_i^{(\nu)} = F_h^{(\nu)} + F_0^{(\nu)}$, $F_0^{(\nu)}$ being a particular integral. Making $\Delta F_0^{(\nu)} = -2(m+1)\,m^{-1}\sigma\alpha T^{(\nu)}$, it follows that $\Delta\Delta F_0^{(\nu)} = 0$. The border conditions are $F_i^{(\mathrm{I})} = F_i^{(\mathrm{II})} = \partial F_i^{(\mathrm{I})}/\partial n = 0$ for all the boundary and also for $x = 0$. The boundary values for $F_h^{(\mathrm{I})}$ and $F_h^{(\mathrm{II})}$ are established as a variational problem introducing $\varphi^{(\nu)} = \Delta F_h^{(\nu)}$ (ν = I, II), resulting in expressions for $\varphi^{(\nu)}$ consisting of two Fourier series with $2n$ coefficients as unknowns. The supplementary conditions are then obtained by equalizing the displacements of both plates for $x = 0$, which permits solution for the $2n$ Fourier coefficients.

E. Fliess, Argentina

1742. **Radzimovsky, E. I., Stress distribution and strength condition of two rolling cylinders pressed together,** Univ. Ill. Engng. Exp. Sta. Bull. ser. no. 408, 40 pp., Feb. 1953.

Author reviews literature of this elastic contact problem at some length, then gives two methods of calculating the stresses in the contact zone, one of which is based on Belayev's analysis. The variation of these stresses during a loading cycle is investigated and plotted at various distances from the contact surface between cylinders. Taking the $x-y$ plane perpendicular to the axes of the cylinders with y in the plane of contact, it is concluded that, under conditions of cyclic loading, the location of the peak value of the shear τ_{xy} determines the zone of failure, rather than the location of the peak value of the maximum shear stress. Latter occurs near $x = 0.78b$ ($2b$ = width of contact strip), while τ_{xy} reaches its peak near $x = 0.5b$. Author notes that maximum

shear may still govern failure under static loading, as advocated in some of his references, since it reaches a slightly larger peak than τ_{xy}. Latter, however, undergoes a complete reversal during each loading cycle.

Author then applies the Huber-Mises criterion for static failure to cyclic loading, in the modified form devised for this purpose by S. V. Sorensen, and reduces the dynamic stresses to equivalent static form by means of Goodman's linear relation. In these calculations, the tensile yield stress is used as an approximation for the endurance limit in variable compressive loading between zero and a maximum. Although the peak values of the normal stresses are not in phase with the peak of τ_{xy} during the loading cycle, author describes tests by Sorensen indicating that this does not affect bending-torsion endurance limits, and neglects the phase difference in subsequent strength calculations.

The limiting value of the maximum normal contact pressure at which fatigue failure begins anywhere is called the "surface endurance limit" (σ_g). This is calculated for several steels ranging from soft to hard, based on their known or estimated properties. Author finds the critical depth for fatigue failure is closer to contact surface for soft than for hard steels, but for all cases it is nearer the surface than the point of maximum shear stress. He suggests that this may explain discrepancies between the tests of previous workers.

Using Dëhmer's relation to convert ultimate strength to Brinell hardness, author then compares his calculations for σ_g with Way's tests on rollers and with Buckingham's recommended values for gear drives. Satisfactory correlation is obtained. Finally, further research is suggested. J. L. Lubkin, USA

1743. Manson, S. S., Behavior of materials under conditions of thermal stress, *NACA TN* 2933, 105 pp., July 1953.

See AMR **7**, Rev. 436.

Experimental Stress Analysis

(See also Rev. 1824)

1744. Bayoumi, S. E. A., and Frankl, E. K., Fundamental relations in photoplasticity, *Brit. J. appl. Phys.* **4**, 10, 306–310, Oct. 1953.

The procedure proposed is to take two fringe photographs of the same model; one under load, the second immediately after removal of the load. The difference between the fringe count at corresponding points is said to give the stress difference in the elastic-plastic body under load. It would appear to reviewer that the procedure will give the stress distribution in an elastic body if no plastic flow will occur on unloading and will be uninterpretable if flow does occur. The authors seem to have overlooked residual stresses which remain.

Relative retardation is expressed as a linear function of stress and strain difference. Experimental verification is provided by the addition of a uniaxial tensile stress at an angle to an initial frozen pattern of tensile stress. This technique was applied previously by the reviewer to obtain stress concentrations in bent plates [*J. appl. Mech.* **9**, A-161–164, 1942]. The more general applicability of the linear relation is not clear.

D. C. Drucker, USA

1745. Poritsky, H., and Jerrard, R. P., Calculation of elastic displacements from photoelastic curves, *J. appl. Mech.* **20**, 3, 375–380, Sept. 1953.

A method is given for calculating two-dimensional displacements and rotations of isotropic elastic bodies, in equilibrium, from photoelastic fringe patterns. An application is given to the calculation of rotations along the center line of a stepped beam in simple bending. R. D. Mindlin, USA

1746. Wright, J., The isodynamometer, *Civ. Engng. Lond.* **48**, 568, 938–942, Oct. 1953.

Author describes new instrument and technique for structural analysis by means of plastic models. Method consists of separating model at section where moment and thrust are to be determined and joining it by mounting isodynamometer. Joint is made flexurally equivalent to member it replaces by transverse arms adjacent to joint. Instrument is made of two arms pivoted at one end and connected at the other through a U-shaped member called "isodynamometer balance." External load is applied to model through a "compensating balance," the two balances having same dimensions and made from same material as model to compensate for creep. Relative deflections of balances are used to calculate results. Author presents experimental data on simple portal frame and reports an accuracy of 1%.

A. Yorgiadis, USA

1747. Bonvalet, C., and Cakiroglu, A., Model experiments with flat slabs (in French), *Ann. Inst. tech Bât. Trav. publics* **6**, 67–68, 673–696, July-Aug. 1953.

The experiments were performed with two rectangular steel plates. Both models were supported in the middle by a row of six nonfixed-end columns. The longer edges of the first model were supported by similar rows of columns. For the second model these edges were given a continuous simple support. Authors show that the reactions at the supports cannot be computed from experimentally determined influence coefficients. Two other methods are described, both leading to satisfactory results for the first model under a uniformly distributed load. One of them is a straightforward measurement by means of a dynamometer at the place of a column. This method is followed in the further investigations concerning the reactions under a load uniformly distributed over a part as well as over the whole area of the plates. After a preliminary analysis, using crackling lacquers, the bending moments are determined by strain-gage measurements. The moments at the periphery of the columns proved to be very sensitive to the diameter of the supports, and for this dependency an empirical formula is derived. As to the measured influence of a possible settlement of one column, reviewer believes the extent of the settlement could have been defined more clearly. Paper concludes with a discussion of the results of some additional tests, from which the influence of a clamping of the column ends may be estimated.

J. F. Besseling, Holland

Rods, Beams, Shafts, Springs, Cables, etc.

(See Revs. 1734, 1745, 1773, 1787, 1789, 1796)

Plates, Disks, Shells, Membranes

(See also Revs. 1694, 1721, 1722, 1738, 1740, 1742, 1747, 1762, 1763, 1764, 1887)

1748. Hoff, N. J., Kempner, J., and Pohle, F. V., Line load applied along generators of thin-walled circular cylindrical shells of finite length, *Quart. appl. Math.* **11**, 4, 411–425, Jan. 1954.

After summarizing the literature on the subject, authors take as the starting point for their derivations a simplified statement proposed by Donnell (to be found in his treatise on stability of thin-walled tubes under torsion, *NACA TR* 479, 1933) and later recommended by Batdorf [*NACA TR* 874, 1947]. In addition

to the eighth-order differential equation in w (radial displacement), two fourth-order equations (in u and w, v and w, respectively—where w and v represent the axial and tangential displacements) are satisfied rigorously. It is assumed that the edges of the cylinder are simply supported (w vanishes therefore at the ends; so do the axial membrane stress and the axial moment resultant, but not the membrane shear stress).

The following line load systems are treated: Sinusoidally distributed radial force (symmetric with respect to the midpoint ($x = 0$) of the generator; constant radial force over segment of generator; sinusoidally distributed radial force antisymmetric with respect to $x = 0$; sinusoidally distributed circumferential moment symmetric with respect to $x = 0$; constant circumferential moment over segment of generator.

C. B. Biezeno, Holland

1749. **Auge, J., Elastic shells with membrane forces only** (in Spanish), *Inform. Construc.* **6**, 54, 445-3, 6 pp., Oct. 1953.

On the basis of the membrane theory of shells, author obtains expressions for the shape and variation in thickness of shells of constant strength under their own weight. Use is made of the concepts and notation of Blaschke, as presented in his book "Einfuhrung in die Differentialgeometrie." Shells whose surface is cylindrical and those which form a surface of revolution are considered.

J. Michalos, USA

1750. **Shaw, F. S., and Perrone, N., A numerical solution for the nonlinear deflection of membranes,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-36, 12 pp.

The nonlinear plate equations are integrated by means of numerical methods, using finite-difference approximations and relaxation-iteration procedures. A rectangular membrane under constant loading forces is treated in detail as an example.

H. Neuber, Germany

1751. **Baker, A. L. L., A graphical method of designing cylindrical shells,** *Concr. constr. Engng.* **48,** 9, 303-306, Sept. 1953.

1752. **Hopkins, H. G., and Prager, W., The load carrying capacities of circular plates,** *J. Mech. Phys. Solids* **2,** 1, 1-13, Oct. 1953.

Paper deals with problem of determining the ultimate load-carrying capacities of circular plates. Only rotationally symmetric loads are studied for plates either simply supported or clamped. Material is assumed perfectly plastic, rigid elastically. Tresca yield condition with its associated flow rule is used. Calculation details and results are presented for case of uniform load distributed over circular area smaller than plate area. Results only are included for case of load uniformly distributed over an annulus whose outer boundary is the plate boundary.

Paper is very clearly written. An important contribution is the demonstration of the relative simplicity of use of Tresca yield condition instead of the von Mises condition.

H. J. Plass, Jr., USA

1753. **Reismann, H., Bending of circular and ring-shaped plates on an elastic foundation,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-7, 7 pp.

Under the usual assumptions made in the treatment of small deflections of thin plates, a solution is obtained for the deflection of the median plane in the case of a ring resting on an elastic foundation, clamped at the edge, and acted upon by a concentrated force. Also a solution is given to a problem in which a bending moment is applied to a disk to which an infinite plate resting on elastic foundation is attached.

W. Ornstein, USA

1754. **Merlino, F. S., Problems concerning a fixed-edge circular plate on an elastic foundation** (in Italian), *G. Gen. civ.* **91,** 9, 535-537, Sept. 1953.

For a plate of constant thickness, boundary moments and shears due to uniform line loads around any circumference and uniformly distributed loads within any circumference are obtained. Author uses the known solution for symmetrical deflections when only boundary forces act [see, e.g., Timoshenko, "Theory of plates and shells," 1940, p. 276], together with Betti's reciprocal theorem and the principle of superposition.

F. DiMaggio, USA

1755. **Bar, J., A method of designing slabs,** *Concr. constr. Engng.* **48,** 11, 355-358, Nov. 1953.

Empirical method is used as a result of tests and is based on the proposition that the shape of the deflected surface of a reinforced-concrete slab is dependent upon the arrangement of the bars provided that the spans and loads are the same. The bars should be arranged in two directions at right angles to the directions of the greatest moments on the slab, the greatest amount of steel being placed where the largest deformations would occur in order to reduce these deformations, and the bars bent so as to follow the distribution of the stresses. The bending moments for which the steel is calculated are the greatest moment on the slab, the moment at a right angle to the greatest moment, the moments along the edges of the slab, the torsional moments at the corners, and the moments at the supports. Other bending moments are not significant.

From author's summary

1756. **Hageman, J. G., Tests on a steel model of a flat slab floor** (in Dutch), *Ingenieur* **65,** 25, Bt. 45-Bt. 53, June 1953.

By means of a steel model the Committee for Research on Constructions T.N.O. investigated the conduct of an ideal square central panel of a flat slab floor with uniformly distributed and with concentrated loads. The theoretical investigation was based on the theory of A. M. Haas, who took into account the influence of the column capital on the stress distribution in the floor. The results of the T.N.O. investigation were compared with the latest American Building Code requirements for reinforced concrete (A.C.I. 318-51) and with tests made by M. Roš.

From author's summary

1757. **Dow, N. F., Hickman, W. A., and Rosen, B. W., Data on the compressive strength of skin-stringer panels of various materials,** *NACA TN* 3064, 49 pp., Jan. 1954.

Edge-compression tests were made on stiffened-sheet panels of stainless steel, mild steel, titanium, copper, four aluminum alloys, and a magnesium alloy. The test results are presented in groups to show the effects of (1) a variation in compressive yield strength with constant modulus of elasticity, (2) a variation in modulus of elasticity with constant yield strength, and (3) a variation of both compressive yield strength and modulus of elasticity with constant strain at the compressive yield strength.

The zee-shaped stiffeners were formed from sheet of the same thickness as that to which they were riveted. Variations in cross section were obtained by varying the spacing and depth of the stiffeners. Length was also a variable.

The stress-deformation curves and buckling stress are given for each specimen.

Marshall Holt, USA

1758. **Mansfield, E. H., Neutral holes in plane sheet-reinforced holes which are elastically equivalent to the uncut sheet,** *Quart. J. Mech. appl. Math.* **6,** part 3, 370-378, Sept. 1953.

Formulas are developed to determine both the shape of a neutral hole and the variation along the hole boundary of the cross-sectional area of the reinforcement. Merely from considerations

of statics, author gets the following equation for the shape of a neutral hole, $\Phi + ax + by + c = 0$ (Φ is the Airy stress function for given stresses in the uncut sheet, a, b, and c are integration constants). The equation is independent of the elastic properties of the sheet. Author gives examples on the shape of holes for different uniform stress distributions.

For holes bounded by arcs of curves, balancing loads must be applied at the junction points of adjacent arcs. Such balancing loads can normally be produced by inserting a tension or compression member from one junction point to another.

The weight of the reinforcement is usually greater than the weight of the sheet that has been cut out, though there are exceptions. Author shows such an exception.

E. Steneroth, Sweden

Buckling Problems

(See also Rev. 1767)

1759. Kroll, Wilhelmina D., Mordfin, L., and Garland, W. A., Investigation of sandwich construction under lateral and axial loads, *NACA TN* 3090, 58 pp., Dec. 1953.

Tests under combined axial load and lateral pressure were made on twelve bonded sandwich panels with simply supported loaded edges and free unloaded edges. The panels were nominally 30 in. long, 17 in. wide, and $^1/_2$ or $^3/_4$ in. thick. The sheets were 75S-T6 alclad aluminum alloy, 0.025 or 0.032 in. thick. The core was a hexagonal honeycomb of 0.005-in. 2S-H18 aluminum foil. The maximum load and the mode of failure were observed for all the panels. Lateral deflections and axial strains were also measured.

Comparison of computed values of lateral deflection and axial strain with experimental values showed that, in most cases, the theory was conservative in predicting larger strains or deflections than those measured. This discrepancy is attributed to the fact that the sandwich-column theory does not take into account the anticlastic bending which was observed in the panel tests.

From authors' summary

Added note by reviewer: All reliable tests with combined load showed failure by local skin buckling. The theoretical ultimate load was computed by assuming maximum strain at failure to be yield-point strain for metal. Paper contains interesting data which should be useful in developing design procedures.

S. U. Benscoter, USA

1760. Chilver, A. H., A generalised approach to the local instability of certain thin-walled struts, *Aero. Quart.* 4, part 3, 245–260, Aug. 1953.

Author sets up exact elastic stability determinant for the local instability of uniformly compressed thin-walled open-section struts composed of a number of flat component plates. The edges of each plate are assumed to remain straight and undeflected; the angle between plates is assumed to remain unchanged. The effect of reinforcing flanges attached to the extreme plate components is considered in the analysis. Buckling is shown to occur in a mode such that all component plates have the same buckle wave length.

The stability determinant is shown to be expressible in terms of seven basic functions for uniformly compressed plates with simply supported loaded edges and various conditions along the unloaded edges. The order of the stability determinant depends upon the number of components involved.

Numerical calculations are given in chart form for "square" channel struts with reinforcing flanges (for various amounts of reinforcement). These charts indicate the possibility of a wave length of buckling that is longer than is commonly associated with local instability problems.

P. Seide, USA

1761. Hunter-Tod, J. H., The elastic stability of sandwich plates, *Aero. Res. Counc. Lond. Rep. Mem.* 278, 39 pp., Mar. 1949, published 1953.

See AMR 3, Rev. 1251.

1762. Nash, W. A., Buckling of multiple-bay ring-reinforced cylindrical shells subject to hydrostatic pressure, *J. appl. Mech.* 20, 4, 469–474, Dec. 1953.

Analysis is given of the elastic instability of a closed, multiple-bay, ring-reinforced cylindrical shell subject to hydrostatic pressure. A standard energy method is used and interbay instability is only discussed. The influence of the rings upon the initial stress distribution is neglected, and analysis is given for rings of finite stiffness as well as for indefinitely great stiffness. The distinguishing feature of the present paper is that the chosen form of buckling distortion is based upon experimental evidence. A numerical example is worked.

Author gives little discussion of experimental results except to note that theoretical values of instability pressures overestimate the experimental values. In reviewer's opinion, this discrepancy is directly attributable to small-deflection theory. Unfortunately, a large-deflection theory would be extremely difficult to apply in the present case because of severe computational difficulties.

H. G. Hopkins, USA

1763. Nardo, S. V., An exact solution for the buckling load of flat sandwich panels with loaded edges clamped, *J. aero. Sci.* 20, 9, 605–612, Sept. 1953.

The solution is based on small-deflection theory and it is assumed that the stresses are within the proportional limit. An exact solution is given for the buckling load of a flat sandwich panel, with loaded edges clamped and unloaded edges simply supported. The equations of equilibrium and the boundary conditions are satisfied identically. Design charts are presented giving the buckling load as a function of the plate aspect ratio and the ratio of core to plate thickness. Also the ratio of shear rigidity to bending rigidity is given as a parameter for these curves. The theory is shown to be in reasonable agreement with the experimental test results.

G. V. R. Rao, USA

1764. Bijlaard, P. P., and Wiseman, H. A. B., On theories of plasticity and the plastic stability of cruciform sections, *J. aero. Sci.* 20, 11, 787–789, Nov. 1953.

Many papers have dealt with the question of why plastic buckling of plates is generally in good agreement with deformation theory of plasticity and in poor agreement with flow theory. Onat and Drucker [AMR 7, Rev. 492] argued that (1) direct tests of plasticity laws are in substantial agreement with flow theory, and (2) buckling data are also in agreement if initial eccentricities are properly taken into account, as indicated by their computation of a special case of an eccentric hinged flange.

Title paper, written in rebuttal, advances view that (1) direct tests of plasticity are much closer to deformation than flow theory, as indicated by tests at Pennsylvania State College, and (2) the agreement between flow and deformation theory predictions in special case calculated by Onat and Drucker is fortuitous, as substantial changes in either specimen dimension or shape of tensile stress-strain curve will eliminate agreement. Latter contention is supported by curves derived by authors from theory of Onat and Drucker.

S. B. Batdorf, USA

1765. **Clark, J. W., Plastic buckling of eccentrically loaded aluminum alloy columns,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 299, 19 pp., Oct. 1953.

Tests were carried out on 61S-T6 rolled rectangular bar and drawn rectangular tube columns, ranging in slenderness ratios between 26 and 110. Eccentricities, determined from measured strain and deflection data in the elastic range, were up to nearly half the depth of the cross section. Three methods of simulating simply supported ends were employed.

Good agreement was obtained between measured load-deflection and load-extreme fiber-strain curves and those computed by assuming one-parameter or three-parameter deflection curves. The interaction formula $P/P' + M/[M'(1 - P/P_E)] = 1$ agreed best with test results and is recommended for design purposes. P and M are compressive load and primary bending moment (i.e., load times eccentricity), P' and M' are critical axial load and critical bending moment, and P_E is Euler critical load. Some data are given on behavior of test specimens after passing maximum load. F. J. Plantema, Holland

Structures

(See also Revs. 1726, 1732, 1746, 1756, 1759, 1790, 1796, 1797, 1802, 2015, 2016)

1766. **Muller, P., Torsion of box girder with elastically deformable cross section** (in German), *Schweiz. Bauztg.* **71,** 46, 673–676, Nov. 1953.

In a bridge whose structure is of the box-girder type, some design formulas hold when the box section is sufficiently rigid to be considered nondeformable. Author considers thin-walled symmetrical box girders which suffer a torsional deformation due to normal loads inducing this torsional moment. Employing the equilibrium of all moment and axial forces (linear, flexure stresses), author shows that the angular deformation of the cross section satisfies the same fourth-order differential equation as the flexible beam supported on an elastic foundation. Some cases of influence lines for shearing forces on the girders are given for special loadings. D. L. Holl, USA

1767. **Chilver, A. H., The stability and strength of thin-walled steel struts,** *Engineer, Lond.* **196,** 5089, 180–183, Aug. 1953.

Article concerns compression strength of steel channel sections formed by cold rolling or pressing thin flat steel strip. Local instability failure is investigated and theory predicts with reasonable accuracy the strength of these sections. It is shown that after elastic buckling has occurred, a strut may have considerable reserve of strength before complete collapse of the cross section takes place. Large series of tests on plain and lipped channels is fully reported, and existing theory is summarized in analytical and graphical form, together with curves derived from author's tests. J. Heyman, England

1768. **Terrington, J. S., and Hawkes, J. M., Crane gantry girders for steelworks,** *Struct. Engr.* **31,** 10, 268–285, Oct. 1953.

1769. **Floor, W. K. G., Shear tests on 24S-T unstiffened and stiffened webs with flanged holes Part I,** *Nat. LuchtLab. Amsterdam Rap.* S.413, 117 pp., July 1953.

Using an improved loading method, an extensive series of tests is reported. It was found that none of the four different types of flanges is superior to the other types, the outer diameter of the flange being specified. The buckling stresses, yield stresses, and ultimate allowable stresses are presented in diagrams. Suggestions are formulated as to the prediction of such stresses. G. Herrmann, USA

1770. **Baldacci, R. F., On iteration procedures in the analysis of hyperstatic systems** (in Italian), *Atti Ist. Sci. Costruz. Univ. Pisa Pubbl.* no. 24, 5 pp., 1952.

A well-known iteration method derived from energy considerations is used to analyze statically indeterminate structures. The convergence and the degree of approximation of the method are discussed. From author's summary by E. Volterra, USA

1771. **Gallia, A., Design of cantilever slab bridges with stiffened kerbs,** *Concr. Constr. Engng.* **48,** 10, 315–322, Oct. 1953.

1772. **Biekart, F. H., A new prestressed concrete viaduct at Nijmegen, designed according to new principles** (in Dutch), *Ingenieur* **65,** 52, 81–87, Dec. 1953.

Paper describes a heavily loaded prestressed-concrete bridge erected in Netherlands, having a total length of 260 ft and a width of 64 ft; it is a continuous structure with three equal spans of 85 ft each.

Usually, the prestressing of a continuous beam induces secondary moments (called parasitic by G. Magnel) which complicate the design and diminish the benefit of choosing a statically indeterminate structure.

The bridge under review consists of 41 separate I-beams, the majority of which are prefabricated; these beams are 17 or 34 ft longer than one span of the bridge and are first placed on simple supports; they are interlaced over the two intermediate piers of the bridge, and the width of their flanges is reduced in these interlacing regions. Then, additional concrete is poured between the beams over the intermediate piers in order to insure continuity of the entire bridge.

According to the author, this new method of construction has economical advantages and insures that no parasitic moments are introduced in the structure.

This reviewer is not convinced that the described method is really competitive with the usual one and questions whether it does not pay too much for the advantage of suppressing the parasitic moments. Ch. Massonnet, Belgium

1773. **Revesz, S., Factors governing the ultimate bending moment of normal reinforced and prestressed concrete beams, with reference to a proposed plastic theory,** *Mag. Concr. Res.* no. 13, 11–26, Aug. 1953.

Tests of beams (a) normally reinforced, (b) pretensioned, (c) posttensioned unbounded, (d) posttensioned grouted, are classified according to type of bending failure and compared with a proposed ultimate load theory in which shape of the compression stress diagram varies with ultimate bending moment. Author also discusses limit of serviceability, fatigue, and safety factor with a view to recommendation of "limiting" values of ultimate bending moment. G. P. Fisher, USA

1774. **Franz, G., Fundamental considerations concerning the prestressing of surface structures** (in German), *Beton u. Stahlbeton.* **48,** 4, 5, 6; 78–83, 120–123, 140–144, Apr., May, June 1953.

Author discusses the problems that are brought on by prestressing of three-dimensional structures. Among the more important findings are: (1) No prestressing without dimensional changes. (2) In computing prestressed concrete, consider the need for compatibility of interior and exterior prestressing.

(3) Effect of shear loading, anchoring forces (axial forces), and eccentric anchoring forces to be separated for computation. (4) "No moments under dead load" has importance only when dead load is substantially larger than live load. (5) Prestressing forces will not change relatively when creep occurs, but these forces will be reduced in proportion to the reduction in the tension of the steel. (6) Local prestressing of domes will usually produce bending. (7) Coincidence of compressive and tensile resultants during the prestressing period only can usually not be obtained in case of flat slabs except by accident. (8) Prestressing of a three-dimensional system in one direction will have influence in the other direction, i.e., both assist each other.

W. H. Gumpertz, USA

1775. **Muller, J., Continuous prestressed concrete structural design,** Proc. Western Conf. Prestressed Concrete, Univ. of Calif., Los Angeles, Nov. 1952; 109–132, Jan. 1953.

First part of paper deals with calculations of the location of the pressure line in continuous structures of prestressed concrete. Examples are given. Last part of paper deals with the effect of plasticity, effect of cracking, and with the possibility of regulating the stress distributions by adjusting the supports of the structure.

C. J. Bernhardt, Norway

1776. **Design of specification PN/B-03250 "Concrete constructions, statical analysis and design," with Prof. Dr. L. Suwalski's commentary,** *Inżyn. Budown.* **9**, 12, 388–395, Dec. 1952.

In 1950, PN/B-03260 was introduced in Poland as a new specification for analysis of reinforced-concrete construction. Instead of being based on the hitherto conventional method of linear stresses with rectangular distribution of stresses in the concrete compression zone of bent beams, the new specification is based on the calculation of reinforced-concrete elements by the method of plastic deformations. For concrete constructions, a new specification PN/B-03250 was outlined in conjunction with the reinforced-concrete specifications. This specification provides for the use of different grades of cement (based on 28 days' compression strength) from 50–600.

Columns are calculated according to the destruction force, which is divided by the appropriate factor of safety to give the live load on the columns. Bent beams are analyzed in analogous fashion based on their failure moment. If one assumes that R is the calculated required tensile strength for bending, S a safety factor, M_n a failure moment, and W the section bending modulus, then $M = M_n/S = WR/S$. Moreover, for a rectangular section $W = kbh^2/6$, not as hitherto $W = bh^2/6$. The value of R for the lowest cement grade is 2.2 and for the highest 1.5, based on a parabolic shape of the curve of tensile stresses. In the analysis of the deflection of columns subject to buckling, both the slenderness of the column and the grade of cement are taken into account.

Introducing this specification has developed plasticity theory into a practical and useful tool for the calculation of concrete elements.

J. Nechay, Poland

1777. **Craemer, H., Theory of plasticity in reinforced concrete [Teorija plasticiteta u armiranog betona],** Belgrad, Izdav. Preduz. Minist. Gardjev., 1951, 309 pp.

In many countries the methods for determining dimensions of cross sections for reinforced-concrete constructions are changing from those of the theory of elasticity ("n" method of admissible tensions) to methods resting on the plastic behavior of steel and concrete in method free from "n" rupture. The improvements and timeliness of this book are, therefore, not to be doubted.

Author gives a clear and comprehensive summary of the fundamental laws proving the validity of this form of calculation. The load capacity on the various types of loading and the degree of safety are carefully discussed on the basis of results given in the earlier chapters. At the end of the book, auxiliary tables for the determination of cross-section dimensions are given.

A chapter treats the load capacity of statically indeterminate systems (beams, girder grillages, frames, and arches); another deals with crosswise reinforced slabs and flat slabs. Methods are developed which enable more rapid calculation than is possible with methods based on the theory of elasticity.

The reviewer believes that constructions calculated by these methods show a more uniform degree of safety in all their parts than those calculated with "admissible tensions."

The book has a valuable bibliography of about 100 titles. Reading the book will be profitable not only for students but for civil engineers as well, since the author deals with numerous specific design cases.

G. Brandes, Germany

1778. **Bergstrom, S.-G., Stable concrete mixes** (in French), *Rev. Matér. Constr.* no. 454, 197–206, July 1953.

See AMR **5**, Rev. 3424.

1779. **Bendel, L., Stresses on piles and walls during pile driving,** Proc. Third Inter. Conf. Soil Mech. Foundation Engng., Aug. 16–27, 1953, vol. II, 7–9.

1780. **Buisson, M., and Chapon, M., Relation between the static and dynamic resistance of piles** (in French), Proc. Third Inter. Conf. Soil Mech. Foundation Engng., Aug. 16–27, 1953, vol. II, 16–21.

1781. **Anonymous, Spillway and conduits for Pine Flat Dam, Kings River, California,** *Wwys. Exp. Sta. tech. Memo.* **2–375**, 80 pp., Dec. 1953.

Model investigations of Pine Flat Dam were concerned with the hydraulic performance of the spillway, energy dissipator, and conduit outlets. Four undistorted scale models were used in accomplishing the investigations: (a) A 1:60-scale comprehensive model; (b) a 1:40-scale section model of the spillway crest; (c) a 1:18-scale model of one conduit of the upper tier of conduits; and (d) a 1:18-scale model of the outlet portal for the conduits of the lower tier.

Results of tests on the spillway crest were of particular interest in that the ogee crest was shaped to fit the underside of the nappe for a head of 39 ft, whereas the maximum pool for which the dam was designed will create a head of 53.1 ft on the spillway crest. Although negative pressures were measured on the spillway crest at the maximum head, tests in a vacuum apparatus indicated that the spillway nappe will not spring free from the ogee crest nor will cavitation occur on the crest. Capacity of the crest at the maximum head was slightly greater than that computed.

A flip bucket with a radius of 50 ft, terminated at a slope of 20 deg above the horizontal, was deemed adequate for protection of the toe of the dam against harmful erosion.

Initial tests indicated the necessity for revision of the outlets of the conduits in both tiers. Undesirable flow conditions in the flip bucket and exit area, produced by flow from the upper tier of conduits, were corrected by turning the outlet portions of the conduits downward on a parabolic curve which terminated tangent to the spillway face. Negative pressures in the cavitation range were eliminated in the outlet portals of the lower-tier conduits by recessing the face of the spillway around the tetrahedral floor deflectors used to disperse the jets emerging from the conduits.

From summary

1782. **Fox, N. L., and Harvey, S. J., Effect of aircraft jet engine exhaust impinging on airfield surfaces,** *Douglas Aircr. Co. Rep.* SM-14735, 45 pp., Dec. 1953.

Available information regarding the effect of aircraft jet-engine wakes on airfield surfacing materials is summarized and discussed. These data show that the temperature of the exhaust gases incident on the pavement surface may be predicted from the exhaust gas temperature, jet nozzle angle, and height-to-diameter ratio. Temperatures in the pavement may then be predicted from the thermal properties of the material and the time of exposure. Moving nonafterburning aircraft do no damage because of the limited time of exposure; stationary nonafterburning and slowly moving afterburning aircraft may produce pavement surface temperatures sufficient to cause appreciable damage. This damage starts at about 300 F for asphalt and 800 F for concrete pavements in current use. The problem of loose material being blown away is more severe than, but similar to, the situation with propeller slip streams. Danger of fires from jet-engine wakes seems remote.

From authors' summary

1783. **Ljungström, O., Wing structures of future aircraft** (in Swedish), *Tekn. Tidsk.* **83,** 30, 609–619, Aug. 1953.

See AMR **6,** Rev. 3724.

1784. **Saffir, H., The effects on structures of winds of hurricane force,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 206, 19 pp., July 1953.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1764, 1777, 1816, 1827)

1785. **Kempner, J., Creep bending and buckling of linearly viscoelastic columns,** *NACA TN* 3136, 22 pp., Jan. 1954.

Paper develops a general dynamic equation for creep bending in a beam loaded axially and laterally. Material is considered to be linearly viscoelastic. The relation used is based upon a model whose properties are defined by two elasticity and two viscosity coefficients. By the use of this model, a material having an instantaneous and retarded elasticity as well as pure flow can be considered. Equations derived are used to obtain the creep bending deflections for a beam in pure bending and of a column with initial sinusoidal deviation from straightness. A comparison of theoretical results with experimental data is not given, so that the suitability of the relations obtained cannot be determined.

J. Marin, USA

1786. **Kempner, J., Creep bending and buckling of nonlinearly viscoelastic columns,** *NACA TN* 3137, 27 pp., Jan. 1954.

A theoretical small-deflection analysis is made of an idealized H-section beam or column whose material is characterized by a stress-strain-time law of the form $\dot{\epsilon} = (\dot{\sigma}/E_1) + (\sigma^n/\lambda)$. A pure bending moment in the plane of the web is assumed and it was found that the deformations increase linearly with time. The column was assumed to have hinged ends and a slight sinusoidal deviation from straightness in the plane of the web. The increase in lateral deflection under constant axial load below the Euler load was calculated, making specific calculations for the cases $m = 1, 2, 3, 4$, and 5. Except for $m = 1$, the analysis gives deflections approaching infinity in a finite ("critical") time, which decreased very rapidly with increasing end load or increasing initial deviation from straightness. The usual assumptions of plane sections, small deflections, and infinite transverse shear stiffness are made. In addition, for the column, it is assumed that the initial sinusoidal shape is at all times maintained.

A. D. Schwope, USA

1787. **Wang, A. J., Plastic flow in a deeply notched bar with semicircular root,** *Quart. appl. Math.* **11,** 4, 427–438, Jan. 1954.

Paper considers title problem under assumption of a rigid, perfectly plastic material. Stress and velocity equations are set up and integrated independently in the characteristic plane, providing inverse solution to problem. Results are complex and difficult to use for direct solution, so author proposes a combination numerical-graphical procedure. Curves are given showing deformed shape or bar up to theoretical separation. Analysis is simplified by approximating portion of deformed notch by circular arc at each step. Author compares typical results with more exact values to justify approximations.

P. G. Hodge, Jr., USA

1788. **Drucker, D. C., Coulomb friction, plasticity, and limit loads,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-60, 8 pp.

Attention is given to the difference between Coulomb friction and the apparently corresponding resistance to plastic deformation. The limit theorems previously proved for assemblages of perfectly plastic bodies, which state the conditions under which collapse will occur, do not always apply when there is finite sliding friction. Theorems are developed which relate the limit loads with finite Coulomb friction to the extreme cases of zero friction and complete attachment, and also to the case where the frictional interfaces are "cemented" together with a cohesionless soil.

From author's summary by B. Gross, Brazil

1789. **Symonds, P. S., Dynamic load characteristics in plastic bending of beams,** *J. appl. Mech.* **20,** 4, 475–481, Dec. 1953.

Paper continues work previously reported [AMR **6,** Rev. 1531] by using different formulation of the equations and applying them to three types of force pulse: rectangular, half-sine wave, and triangular. Deflections produced by the half-sine wave pulse are fair averages of the deflections for the rectangular and triangular pulses. For one selected pulse amplitude and period, the deflection produced by the half-sine wave is about 16% below the rectangular pulse and about 16% above the triangular pulse.

B. E. Gatewood, USA

1790. **Falconer, B. H., Post buckling behaviour of long square boxes under torsion,** *Engineer, Lond.* **196,** 5105, 690–694, Nov. 1953.

A theoretical analysis is formulated for long square thin-walled (constant thickness), unstiffened boxes subjected to torsion. Particular attention is given to the postbuckling regime and to the effect of initial curvature of the box walls. Due to the nonlinearity of the problem, only an approximate solution could be obtained by making use of the strain energy of the system and by assuming the expression defining the lateral deflection. Graphs showing calculated and experimental results are given and a comparison with the small deflection theory is made.

H. H. Hilton, USA

1791. **Gervais, A. M., Norton, J. T., and Grant, N. J., Kink band formation in high purity aluminum during creep at high temperatures,** *J. Metals* **5,** 11, sect. 2, 1487–1492, Nov. 1953.

An investigation of the creep deformation of coarse-grained specimens of high purity aluminum in the temperature range 800 to 1150 F permitted the formulation of a theory explaining the formation of kink bands. The x-ray Laue back-reflection technique was used in conjunction with metallographic studies to determine the crystallographic elements involved in kinking and to measure the rotations of the bands.

From authors' summary by L. W. Hu, USA

1792. Yakovleva, E. S., and Yakutovich, M. V., The role of grain boundaries in the plastic deformation of aluminum, Nat. Sci. Found. tr-155, Jan. 1954; *Doklady Akad. Nauk SSSR (N.S.)* **90,** 6, 1027–1029, June 1953.

In the present work the effect of temperature on the localization of deformation along the grain boundaries for two different methods of deformation was studied. In one case, the deforming was done at the constant extension rate of 24% per hour; in the other case, the material flowed at a considerably lower rate under a constant load. The study was made with samples which were single crystals in cross section and were composed of two to three crystals in length. Thus, the behavior of the metal at the grain boundaries was not complicated by the effect of the surrounding grains, as in a polycrystal.

From authors' summary

1793. Bishop, J. F. W., On the complete solution to problems of deformation of a plastic-rigid material, *J. Mech. Phys. Solids* **2,** 1, 43–53, Oct. 1953.

Solutions of problems with plastic-rigid materials are usually given as consisting of a kinematically admissible velocity field extending over the entire body and of a statically admissible stress field extending over the region of plastic flow. Such solutions give the correct collapse load only if it is possible to extend the stress field as a statically admissible one over the region assumed to be rigid.

Author gives criteria of acceptance of such extensions of the stress fields. He also gives a method for constructing these extensions and illustrates this method by considering the yielding of notched bars in plane strain and plane stress and the extrusion under plane strain conditions. A. Phillips, USA

1794. Scott, K. W., and Stein, R. S., A molecular theory of stress relaxation in polymeric media, *J. chem. Phys.* **27,** 7, 1281–1286, July 1953.

Paper deals with stress relaxation resulting from chemical reactions causing the breaking of network cross links and the formation of new cross links in the strained state. Kinetic theory of rubber elasticity is applied in the analysis. According to simplified solution, stress decays exponentially, with decay constant slightly dependent on sample elongation.

Theory involves the assumption that chain end displacement vectors, which originally have Gaussian spatial distribution modified by affine transformation of sample elongation, retain the same form of distribution after partial relaxation. To reviewer this assumption seems questionable. M. Mooney, USA

1795. Reiner, M., On volume–viscosity, *Bull. Res. Counc. Israel* **3,** 1/2, 67–71, June/Sept. 1953.

Author considers viscous forces in a liquid depending for their magnitude on the rate of volume change. The instantaneous rate of volume change $\dot{d}_v$ during a deformation process is decomposed into a recoverable part $\dot{e}_v$ and a nonrecoverable part $\dot{f}_v$. The recoverable volume change e_v itself produces a hydrostatic pressure $-ke_v$ (k is elastic bulk modulus). Viscous reactions dependent on $\dot{e}_v$ and $\dot{f}_v$ are considered and the following equations are introduced

$$\dot{d}_v = \dot{e}_v + \dot{f}_v; \quad p_m = -ke_v + \zeta_s \dot{e}_v; \quad p_m = -\zeta_l \dot{f}_v$$

(ζ_s, ζ_l are coefficients of two different kinds of volume viscosity; p_m total hydrostatic pressure). Elimination of e_v and f_v gives

$$p_m + [(\zeta_s + \zeta_l)/k]\dot{p}_m = -\zeta_l \dot{d}_v - (\zeta_l \zeta_s/k)\ddot{d}_v$$

Applications are given of these equations to a few simple cases and some questions are discussed connected with the proper definition of the quantities introduced.

J. M. Burgers, Holland

1796. Knudsen, K. E., Yang, C. H., Johnston, B. G., with appendix by Weiskopf, W. H., Plastic strength and deflections of continuous beams, *Welding J.* **32,** 5, 240s–255s, May 1953.

Several methods for computing deflections of simple and continuous beams through the plastic range to failure, some of them original (and one developed by W. H. Weiskopf in an appendix) are discussed and compared. They are all based on the steel stress-strain diagram and differ only in the type and number of simplifying assumptions. Thus, some take account of the initial region of strain hardening, or the length and extent of plastic zone, etc., while the simpler ones do not. Comparison with tests shows empirical results to differ significantly from those computed by any of these methods, probably because of residual stresses, leading to the conclusion that the simpler methods suffice for an approximate deflection prediction and that further refinements of calculations are useless.

Authors show that for beams with no or small end restraint, deflections become excessive at loads below the ultimate predicted by the simple plastic theory, thus confirming Stüssi's earlier work. It is their opinion, therefore, that this theory may have to be combined for design purposes with deflection limitations at working load or at a stipulated multiple thereof (smaller than the predicted ultimate load).

Paper is valuable in that it deals with the deflection problem in connection with plastic design, a phase which has been neglected by many proponents of that method and to whose importance reviewer drew attention in 1940 in his discussion of Van den Broek's pioneering paper. G. Winter, USA

1797. Johnston, B. G., Yang, C. H., and Beedle, L. S., An evaluation of plastic analysis as applied to structural design, *Welding J.* **32,** 5, 224s–239s, May 1953.

A valuable and level-headed evaluation of the present state of knowledge on plastic analysis as a basis for the design of steel structures, in contrast to conventional, elastic methods. Emphasis is placed on those areas where physical reality departs from the idealized assumptions of the "simple plastic theory" and which are often overlooked by the less critical proponents of wholesale change from elastic to plastic design. Topics discussed are: The problem of limiting deflections under service loads. The fact that the theoretical maximum moment (plastic hinge moment) may in actuality not be reached due to one or more of the following: simultaneous shear stresses; axial loads in frame legs, and the like; local buckling of flanges whose width/thickness ratios may be safe for elastic, but not for plastic, design; lateral buckling in the plastic domain; residual stresses due to cooling and cold-straightening, in magnitudes sometimes approaching the yield point.

Detailed attention is given to the following factors which may make plastic design as customarily understood inapplicable or in need of modification: shear as a primary design criterion, fatigue, brittle fracture. Authors also emphasize problem of connection design in relation to plastic analysis and briefly review the problem of shakedown. The extensive bibliography omits, however, all but one of the numerous foreign-language publications.

G. Winter, USA

1798. Jung, H., Axially symmetrical elastic-plastic body (in German), *Öst. Ing.-Arch.* **7,** 3, 168–180, 1953.

General tensorial relationships are derived for stresses and displacements in an axially symmetric, elastoplastic body based on

Kauderer's [*Ing.-Arch.* **17,** p. 450, 1949] elasticity condition and von Mises-Saint Venant's yield condition. It is assumed that the directions of principal stresses coincide with the directions of principal displacements. Through simplification of these relationships a first- and a second-order theory are evolved.

Part II of this study will deal with the application of above theory to the problem of deep drawing and with the agreement of theoretical and experimental results. D. Kececioglu, USA

1799. **Hopkin, L. M. T., and Thwaites, C. J., The effects of some constitutional factors on the creep and fatigue properties of lead and lead alloys,** *J. Inst. Metals* **82,** 181–196, 3 plates, 1953–1954.

Failure, Mechanics of Solid State

(See also Revs. 1742, 1807, 1810, 1819, 2009)

1800. **Wetenkamp, H. R., Thermal checking of wrought-steel railway wheel material,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-72, 10 pp.

It was noted that small cracks (thermal checks) occurred in the tread of railway-car wheels in addition to the larger thermal cracks, which may cause an explosive-type wheel fracture. Thermal checks and thermal cracks may have the same external appearance; however, the latter are usually longer and always deeper and generally have a more serious effect.

During braking the tread of the wheel can be heated locally to high temperatures with a very steep temperature gradient and, consequently, a steep stress gradient. These high stresses and temperatures may cause plastic deformations, resulting in large residual stresses after cooling to a uniform temperature. Eventually these stresses may give rise to a crack, the formation of which is accompanied by a "ping-ring" sound.

For the development of thermal checks, at least two heating cycles are needed. It is suggested that the first heating cycle raises the temperature locally to such high values that the material deforms plastically due to the compressive stresses resulting from the thermal expansion and that the microstructure consists of an area of mostly coarse martensitic grains. The quenching of the material to martensitic causes an expansion, which counteracts the tensile stress and the result is a material under compressive stress. The second or following heating cycles have a tempering effect, causing a contraction of the martensite, resulting in the development of tensile stresses, which may be sufficient to initiate thermal checks.

A description is presented of test setups under closely controlled conditions. Some of the experimental results are that the thermal check sensitivity increases with increasing carbon content of the steel; that for a given class of steel the thermal checks initiate within a reasonably constant hardness range; and that the checks are intergranular. R. G. Boiten, Holland

1801. **Pavlov, V. A., On the nature of ductile failure of metals** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **91,** 2, 253–255, July 1953.

From previous work [AMR **6,** Revs. 475, 476], author regards ductile fracture as the outcome of two simultaneous and interacting processes: lattice distortion by shear, and microcrack formation by tension. He presents measurements, on several steels, of impact strength vs. previous plastic tensile strain. At strains of 8% or more, all slopes are negative; there is a range of strains over which the decrease is particularly rapid and the scatter large. The usual interpretation of such results is that the prestrain raises the ductile-brittle transition temperature above room temperature; this interpretation is inadmissible here, for the fractures are consistently fibrous. The range of rapid change terminates at a strain equal to the maximum uniform strain attainable before necking. Author interprets this range as one of rapid formation and growth of isolated regions of large distortion, favorable to crack formation.

William Fuller Brown, Jr., USA

1802. **Hempel, M., and Houdremont, E., A contribution to the understanding of the structural changes associated with fatigue of (metallic) materials** (in German), *Stahl u. Eisen* **73,** 23, 1503–1511, Nov. 1953.

Effect of reversed direct fatigue stressing above the fatigue limit on microstructure and x-ray diffraction patterns of 0.02% C steel initially prestretched 18%. Application of a sufficient number of stress cycles results in precipitation of cementite particles along slip lines. After similar tests at −180 C, carbide precipitates were absent but twinning set in instead.

Restoration of sharpness of x-ray patterns by fatigue stressing is ascribed to recovery or recrystallization effects, though no direct proof is presented of the latter's occurrence. Discussion deals with relations between microstructural changes, damping, and inception of structural damage. N. H. Polakowski, USA

1803. **Le Claire, A. D., Diffusion in metals,** Progress in Metal Physics **4,** 265–332, 1953; New York, Interscience Publishers; see also *J. Iron Steel Inst.* **174,** part 3, 229–236, July 1953.

Papers give a critical analysis of postwar work up to 1952 and thus a detailed picture of present state of experimental knowledge and theoretical interpretation. Remarkable progress was initiated in 1946 by the Smigelkas-Kirkendall experiment, leading to the introduction into theory of separate partial diffusion coefficients in multicomponent systems. In quantitative evaluation of chemical diffusion data, caution is necessary because of porosity and similar effects connected with transport of lattice defects; self-diffusion measurements are superior in unobjectionable fundamental significance. Author discusses reasons for the importance of new anelastic methods (internal friction, elastic aftereffect) for determination of diffusion coefficients in a wide temperature range. Evidence is reviewed for the now generally accepted assumption of a vacancy mechanism for diffusion in substitutional alloys with face-centered cubic structures. Grain boundary diffusion is dealt with, stressing the dependence of this effect on grain boundary structure. F. Wever, Germany

1804. **Dekhtyar, I. Y., The dependence of the diffusion coefficient on atomic interaction in metals and alloys,** Nat. Sci. Found. tr-25, June 1953; *Doklady Akad. Nauk SSSR (N.S.)* **89,** 1, 49–52, Mar. 1953.

1805. **Smekal, A. G., Dynamics of brittle fracture of cylindrical glass rods** (in German), *Öst. Akad. Wiss. math-nat. Kl. S.B.* **161,** 9/10, 361–373, 1952.

Pure cleavage fractures of rods in simple tension. Appearance of fracture surfaces indicated fractures usually began at some point of "eigenspannung" or microstrain, a region of locked-in strain of dimensions below one micron, rather than at bubbles, foreign particles, or Griffith cracks. Fracture advances from this point in circular fracture front. Fracture-front shape and velocity are determined for several fractures beginning at edge point, assuming only that velocity of weak spherical elastic waves is constant at sound velocity. Weak microstrain points are introduced at rod surface by grinding or emery polishing. When advancing fracture front passes one of these microstrain points, it releases a weak spherical elastic wave. Since fracture-

front velocity is less than wave velocity, the intersection of this advancing wave with advancing fracture front traces out a curve line, visible on fracture surface because at intersection the principal stress direction is rotated slightly. The many surface microstrain points produce two intersecting families of such weak traces on fracture surface. Arbitrarily calling time zero at beginning of one trace near initial point, all later points on fracture surface are dated using only known value of sound velocity. Fracture-front velocity is found to increase as front advances, from zero to a value constant for each glass. Faster stress application resulted in higher fracture stress and more rapid increase of fracture-front velocity to its asymptotic value. This is explained by thermal strain mechanism.

Author states that origin of fracture at microstrain points, established in paper through fracture appearance and behavior as stress application rate is changed, along with other recent electron microscope investigation by author, makes the Griffith crack theory meaningless.

Reviewer believes the Smekal microstrain theory, if confirmed by additional independent experimental work, will prove more satisfactory than the Griffith theory in explaining brittle fracture phenomena. Griffith crack formation can be explained by this theory, as part of a more general picture.

R. B. Green, USA

Material Test Techniques

(See also Rev. 1737)

1806. Morrison, D., Deviations from Hooke's law within the "elastic range," *Engineering* **177,** 4592, 141–144, Jan. 1954.

Paper describes an apparatus developed for the measurement of the very small plastic strains occurring in steel at stresses within the so-called elastic limit, such measurements being of particular interest in the study of damping capacity or elastic hysteresis. Author claims that an important feature of the apparatus is that it determines the absolute shape of the loop and not merely its area on strain width. The specimen is subjected to a static bending test, and a mathematical method is given for relating the bending damping coefficient and the pure-tensile damping coefficient. The test results given indicate that the damping coefficient is a function of stress.

Marshall Holt, USA

1807. Hausseguy, L., and Martinod, H., Interesting observations of static tests in the study of the fatigue process (in French), *Rech. aéro.* no. 36, 57–59, Nov.-Dec. 1953.

Authors describe observations of effects of previous alternating stressing on static stress-strain behavior. In a duralumin a decrease in "dispersion" is pointed out; in the carbon steel no change in "dispersion" is found; however, there are apparent changes in the proportional limit and in the flat part of the stress-strain curve. H. J. Grover, USA

1808. Dieter, G. E., and Mehl, R. F., Investigation of the statistical nature of the fatigue of metals, *NACA TN* 3019, 25 pp., Sept. 1953.

Results of tests and study are presented which extend the work of *NACA TN* 2719, confirming in general the statistical properties of fatigue data previously established and indicating essentially the same degree of variations for 24S and 75S aluminum alloys as for steels. Report shows evidence of unusual care and thoroughness, although statement of total numbers of tests is omitted and conclusions rest on equivalence of results from R. R. Moore machines and G. E. vibrating-beam machines, which is not demonstrated experimentally. Reviewer believes this type of analysis is necessary to the definition of fatigue properties; usual "scatter-band" has been widely misconstrued, and rational design perhaps should recognize statistically evaluated deviations of both material properties and applied loads.

P. E. Sandorff, USA

1809. Heywood, R. B., The fatigue testing of structures by the resonance method, *Schweiz. Arch.* **19,** 8, 249–260, Aug. 1953.

Paper describes and compares fatigue-testing machines for testing parts or structures at frequency close to resonance. Special emphasis is given to methods used for testing aircraft structures.

It is demonstrated that testing at or near resonance can be employed successfully for testing both large and small structures. Method entails work in arriving at correct loading distribution in structure, but the test itself is rapid. Particular interest is shown in "slip clutch" type of exciter which not only forms means of excitation but also controls amplitude of vibrations.

D. E. Hardenbergh, USA

1810. Mowbray, A. Q., Jr., The effect of superposition of stress raisers on members subjected to static or repeated loads, *Proc. Soc. exp. Stress Anal.* **10,** 2, 153–166, 1952.

Author found that effect of cutting a semicircular groove into the surface of a second stress raiser, the latter being of roughly an order of magnitude greater in scale, was to produce an over-all concentration factor approaching the product of the two individual factors. Static tests covered ratios of radius (of the original stress raiser to that of the superimposed groove) ranging from 6 to 19, with over-all concentration factors ranging from 0.79 to 0.89 times the product. In fatigue tests of heat-treated 4340-steel rotating-beam specimens, total strength-reduction factors approximated within usable limits the product of the two fatigue-reduction factors. C. W. Gadd, USA

1811. Lyons, W. J., and Prettyman, I. B., Use of the ballistic pendulum for impact testing of tirecord, *Textile Res. J.* **23,** 12, 917–925, Dec. 1953.

A ballistic pendulum tester for the absolute measurement of the energy (or work) of rupture of cords and yarns on impact is described, and the applied theory of the pendulum is briefly reviewed. Essentially, the test consists of placing a looped specimen, clamped at its ends, in a horizontal plane so that it is struck in the bend of the loop by the pendulum at the bottom of its swing with sufficient energy to break the specimen. The difference in angular displacement of the pendulum with and without a specimen in place provides the measure of the energy lost in breaking the specimen.

For expressing the results of the test as applied to tirecord, with reference to various conditions, four physical quantities have been defined. The significance of these quantities is discussed and the results of exploratory tests on a number of rayon constructions are given, showing the application of the various measures.

By means of high-speed photography, used in connection with the pendulum apparatus, the impact-rupture process in tirecord is analyzed. From authors' summary

1812. Krisch, A., Notch impact tests according to H. M. Schnadt (in German), *Stahl u. Eisen* **19,** 73, 1215–1225, Sept. 1953.

The suggestions of Schnadt for the testing of steels by impact tests are critically discussed. It is shown that Schnadt's value π used for the characterization of the state of stress corresponds with the proportion σ_v/σ_1, where σ_v is the resultant of stress and σ_1 the value of normal stress.

Suggestions for notch sensitivity tests with impact test bars of

varying notch diameters had already been made by Moser about 20 years ago. An exact stress analysis of such bars is not even possible, according to the suggestions by Schnadt. The new terminology chosen by Schnadt has a confusing effect and renders understanding more difficult. E. Siebel, Germany

1813. **Boller, K. H., Stress-rupture tests of a glass-fabric-base plastic laminate,** *For. Prod. Lab. Rep. U. S. Dept. Agric.* 1839, 14 pp., June 1953.

Stress-rupture tests of a glass-fabric-base plastic laminate made with a typical polyester-type resin show that the maximum tensile stress that can be sustained for a period of 300 hr is, for an unnotched laminate, about 60% of the unnotched static tensile strength, and for a notched laminate, about 55% of the notched static tensile strength. Notching reduces the level of stress that can be sustained for this period to 46% of the static tensile strength of the unnotched laminate, a reduction of about 20%. From author's summary

1814. **Ladisch, R. K., McQue, B., and Knesbach, S. L., Method of measuring ultrafine glass fibers,** *Analytical Chem.* 26, 2, 399–400, Feb. 1954.

Mechanical Properties of Specific Materials

(See also Revs. 1765, 1791, 1792, 1794, 1799, 1800, 1805, 1808, 1813, 1814, 1838, 2046)

©1815. **Moore, H. F., and Moore, M. B., Textbook of the materials of engineering, 8th ed.,** New York, Toronto, London, McGraw-Hill Book Co., Inc., 1953, ix + 372 pp. $6.

This textbook is an elementary introduction to the materials used in engineering. It will serve very well to acquaint the undergraduate student with the information required for structural and machine design. It also contains a great amount of data so as to serve as a valuable handbook for practicing engineers.

The first ten chapters provide the basic definitions of the strength of materials, information on the theories and modes of failure, data on the properties of metals, and information on the production of metals. Topics discussed include slip, spreading of cracks under repeated stress, impact, creep, fatigue, working stress, factor of safety (factor of uncertainty), stress concentration, corrosion, mechanical wear, heat-treatment of metals, alloying, and welding.

The remainder of the book describes the use and properties of the nonmetallic materials such as wood, ceramic materials, cement, concrete, plastics, rubber, and leather. The text ends with chapters on the testing of materials and on the specifications for materials.

The book is written in a clear concise manner and is well arranged. Each chapter concludes with a list of references for those interested in further study. The questions that are located at the end of each chapter make this text a valuable classroom aid. V. P. Zimnoch, USA

1816. **Theis, E., Creep strength and embrittlement of ferritic steels at 550 C** (in German), *Schweiz. Arch.* **19**, 10, 300–315, Oct. 1953.

To increase efficiency of new steam power stations, working temperatures have been gradually increased from 520 up to 600 C, which requires still better creep-resisting steels. In view of this, author reports results of creep-to-rupture tests with various types of ferritic steels at 550 C. Starting point was well-known Cr-Mo-V-steel (1.3% Cr, 0.6% Mo, 0.20% V). It was found that embrittlement during long-time loading could be avoided by adequate heat-treatment, viz., low quenching temperature (920 C) and high drawing temperature (750 C). Although this caused a lower tensile strength and a lower load-to-rupture for 100,000-hr life, extrapolated from creep tests with unnotched bars, the load-to-rupture for 100,000 hr with notched bars (which is, in author's opinion, the true creep strength) was not affected. This true creep strength could be increased by raising vanadium up to 0.70% and molybdenum up to 1.2% (+5 and +3 kg/mm², respectively). Tungsten, up to 1%, had no detectable influence on creep strength and embrittlement. Steels of the type 5% Cr, 0.5% Mo showed, even when quenched from 1030 C, no embrittlement, provided that V was at least 0.30%. By increasing Mo up to 1.2%, creep strength (100,000 hr) could be increased by 2 kg/mm². This type of steel showed a relatively high elongation during creep, which limits its application to parts (e.g., tubes) for which some dimensional changes can be tolerated. The best steel in the investigated ferritic series contained 13% Cr, 1.2% Mo, 0.3% V, 0.8% W. This steel can be used at 600 C, provided Mo amounts to 1.2% min. In regard to elongation during creep, this steel was about equivalent to austenitic steel (16% Cr, 13% Ni, 2.5% Mo). The latter, however, showed higher loads to rupture.
J. H. van der Veen, Holland

1817. **Johnson, J. E., Wood, D. S., and Clark, D. S., Dynamic stress-strain relations for annealed 2S aluminum under compression impact,** *J. appl. Mech.* **20**, 4, 523–529, Dec. 1953.

The results of the investigation show that the behavior of annealed 2S aluminum under conditions of impact loading into the plastic-strain range can be represented to a good approximation by a single dynamic stress-strain relation. This dynamic stress-strain relation lies above the static stress-strain curve. The excess of dynamic stress over the static values increases progressively with strain, reading about 20% of the static stress at a strain of 4.5%.

However, the results also show that higher-order effects cannot be correlated with such a single dynamic stress-strain relation. A detailed analysis of the experimental measurements by means of the von Kármán theory of propagation of plastic strains in long rods indicates that the behavior of the material near the impact surface may be described by a family of stress-strain relations. Each member of this family of curves corresponds to a given impact stress, and the curves are arranged consecutively in order of increasing impact stress. All of these curves lie within a narrow region in the stress-strain plane. From authors' summary

1818. **Hill, H. N., Hartmann, E. C., and Clark, J. W., Designing aluminum alloy members for combined end load and bending,** *Proc. Amer. Soc. civ. Engrs.* **79**, Separ. no. 300, 18 pp., Oct. 1953.

This paper, while more or less summary in nature, presents three major items useful to design engineers:

1 A means of determining an effective column formula when the compressive properties of the matter are known. While the equations for the coefficients in the straight-line column formula are somewhat involved, they do eliminate the personal equation from the determination of these coefficients.

2 The lateral buckling of the compression flange of beams has long been a matter of arbitrary rule for most designers, but from the judicious use of the equation presented in this paper much of the arbitrary matter of such rules can be eliminated.

3 Instead of simply adding the bending stress and the column stress to determine the allowable stresses in a column subjected to bending as well as unload, this paper presents a useful way of taking into account the interaction between the bending and

column action and, therefore, makes possible more rational analysis of such structural members. R. G. Sturm, USA

1819. **Arkharov, V. I., Ignatyeva, S. I., and Kozmanov, Y. D., Thermal fatigue of single crystals of aluminum,** Nat. Sci. Found. tr-3, June 1953; *Dokladi Akad. Nauk SSSR* (*N.S.*) **88**, 3, 439–440, Jan. 1953.

1820. **Crossley, F. A., and Kessler, H. D., Titanium alloys give promise of high temperature applications,** *J. Metals* **6**, 2, 119–121, Feb. 1954.

1821. **Richmond, J. C., Moore, D. G., Kirkpatrick, H. B., and Harrison, W. N., Relation between roughness of interface and adherence of porcelain enamel to steel,** *J. Amer. ceram. Soc.* **36**, 12, 410–414, Dec. 1953.

Porcelain-enamel ground coats were prepared under conditions that gave various degrees of adherence, and adherence and roughness of interface were evaluated. A positive correlation was found between adherence and roughness of interface, and it was concluded that roughness of interface is a necessary but not a sufficient condition for the development of good adherence between a porcelain-enamel ground coat and iron. Most of the roughness that is associated with good adherence apparently develops during the firing process. From authors' summary

1822. **Bergeron, C. G., Relation of bubble structure of porcelain enamel to fish scaling,** *J. Amer. ceram. Soc.* **36**, 11, 373–376, Nov. 1953.

A technique is described for making angular cross sections of enameled steel in order to study the bubble structure of a porcelain enamel. This technique involves cutting a section so that the width of the glass layer is extended, allowing easier observation of bubble size and distribution. From author's summary

1823. **Schmidt, O. H., Ceramic materials for machine parts** (in German), *Technik* **8**, 10, 665–673, Oct. 1953.

Contrary to metals, ceramic materials are brittle and there is no plastic deformation before rupture; however, they have sufficient pressure strength and are excellent in resistance to corrosion and atmospherics. Thermal conductivity is very small and thermal expansion lower than that of metals.

The process of manufacturing ceramics and its relations to design of ceramic machine parts are discussed. Shrinkage of ceramics is large in relation to metals; rules for rational applications of shrinkage allowances are given. Surface shaping by grinding, glazing, metallizing, and die-casting is discussed. Connections with other materials can be made by electrothermal process with metals or by cementing. Most applications are made in electrical and chemical industries; e.g., centrifugal pumps, pipes, valves, vacuum vessels, isolators, etc. New examples are gear wheels and gear units in textile industry, nozzles, engine bases.

Cooperation between mechanical engineers and ceramists is recommended. F. Wever, Germany

1824. **Bartenev, G. M., On the photoelastic constant of glass under large stresses,** Nat. Sci. Found. tr-170, Jan. 1954; *Dokladi Akad. Nauk SSSR* (*N.S.*) **91**, 3, 523–526, July 1953.

It is demonstrated that the photoelastic constant (percentage retardation kg/cm²) has a uniform value of 2.50×10^{-7} up to a stress level of 2500 kg/cm² for glass with a percentage composition as follows: (SiO_2 70.9, Na_2O 16.1, K_2O 0.6, CaO 8.1, MgO 2.9, R_2O_3 0.9). Rectangular bars under pure bending were used. The fracture stress level of the glass was raised, by etching the specimen surfaces with 35% HF, from 600 kg/cm² (unetched) to 2500 kg/cm² (etched) in order to extend the range of investigation. It may be concluded that with this glass the optic law is stress-dependent up to 2500 kg/cm². H. Becker, USA

1825. **Terao, N., Influence of humidity on the strength of glass strip,** *J. phys. Soc. Japan* **8**, 4, 550–552, July-Aug. 1953.

1826. **Kohl, M., Use of glass fibers to reinforce concrete** (in French), *Tech. mod. Constr.* **8**, 8, 265–266, Aug. 1953.

A critical survey is presented on the properties of glass fibers, e.g., the tensile strength, the coefficient of thermal expansion, the chemical and electrical properties, etc. From this, it follows that the material should be very good to reinforce concrete. As of this moment the price of glass fiber cord is still about 7 or 8 times higher than the equivalent high-strength steel wire; its practical application in the near future is not to be expected. R. G. Boiten, Holland

1827. **Knowles, J. K., and Dietz, A. G. H., Viscoelasticity of polymethyl methacrylate—an experimental and analytical study,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-100, 14 pp.

Paper is concerned (a) with a presentation of static tensile stress-strain data under many different experimental conditions on several types of methyl methacrylate, together with an empirical equation to describe them, and (b) with an attempt to correlate the static behavioral characteristics of two varieties of methacrylate by means of an extension of the Boltzmann-Volterra theory of the elastic aftereffect to an extent that facilitates the prediction of creep and constant strain-rate curves from stress-relaxation data to within an error acceptable for engineering purposes. From authors' summary by L. Nielsen, USA

1828. **Hall, H. W., and Russell, E. W., Polymethyl methacrylate (Perspex type) plastics; crazing, thermal and mechanical properties,** *Aero. Res. Counc. Lond. Rep. Mem.* 2764, 27 pp., Oct. 1949, published 1953.

The report summarizes the more practical aspects of the results of a long-term investigation of the basic physical and chemical properties of polymethyl methacrylate (Perspex-type) plastic. Thermal, elastic, crazing, solvent absorption, and mechanical properties are included and the effect of these on the service efficiency of a plastic structure is described.

Tensile, impact, and flexural strengths, together with the effects of temperature, notch sensitivity, solvent, and crazing on them, are given in detail. From authors' summary

1829. **Hollies, N. R. S., Bogaty, H., Hintermaier, J. C., and Harris, M., The nature of a fabric surface: evaluation by a rate-of-cooling method,** *Textile Res. J.* **23**, 11, 763–769, Nov. 1953.

A simple method is given for describing the surface character of fabrics in a quantitative manner. The method is based on cooling-rate determinations at the fabric surface. The results obtained appear to relate to certain characteristics of fabric handle which are generally described subjectively by adjectives on a "hairy-to-smooth" or "warm-to-cool" scale of values.

A theoretical analysis is given of the method presented, which permits interpretation of the results in terms of the number of surface fibers n, their mean length l, and the unit thermal conductance of the fiber k. Application of the theory to simulated pile fabrics of polyethylene and fabrics of wool appears to validate the general correctness of the theory. From authors' summary

1830 **Takamura, Y., Measurement of the net thermal conductivity of fibrous substances,** *J. phys. Soc. Japan*, **8,** 5, 674–676, Sept.-Oct. 1953.

A compressed specimen of dry fiber was idealized into a flat plate whose area was large compared with thickness. The fiber and the air in voids were then considered to be a series path for steady-state heat flow. By summing conductances, a linear expression was obtained, relating total thermal conductivity with thermal conductivity of the fiber and of the air.

Check measurements made with glass wool and cotton indicated that, while the linearity of the expression apparently was valid, the accuracy with which thermal conductivity of the fiber could be determined was indefinite. D. M. Vestal, Jr., USA

1831. **Anonymous, A simple device for detecting compression wood,** *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1390, revised, 7 pp., June 1953.

1832. **Luxford, R. F., and Wood, L. W., Survey of strength and related properties of yellow-poplar,** *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1516, revised, 44 pp., June 1953.

Mechanics of Forming and Cutting

1833. **Leone, W. C., Distribution of shear-zone heat in metal cutting,** *Trans. ASME* **76,** 1, 121–124, Jan. 1954.

When metal is cut, more than half of the total energy employed appears on the shear plane in the form of thermal energy, part of which is convected away by the chip, the remainder being conducted into the workpiece. This paper is concerned with an analytical determination of the distribution of shear-plane thermal energy between chip and workpiece.

M. C. Shaw, USA

1834. **Vieregge, G., The distribution of energy and the temperature during a cutting operation** (in German), *Werkstatt u. Betrieb* **86,** 11, 691–703, Nov. 1953.

Paper fails by giving a purely statical explanation for a dynamical process. It may be that this causes the discrepancies between calculated and measured forces. Based on simplified assumptions for temperature creation and temperature distribution along the boundary, temperature distributions in the workpiece are determined graphically.

F. Schultz-Grunow, Germany

1835. **Shaw, M. C., Cook, N. H., and Smith, P. A., The mechanics of three-dimensional cutting operations,** *Trans. ASME* 74, 6, 1055–1064, 1952.

Paper is a critical review of works of Merchant, Kronenberg, Stabler, and others on the mechanics of three-dimensional cutting. Reference is made to rake angles, angle of inclination of cutting edge, chip-flow direction, velocity and force relations. Experimental data show friction effect on chip-flow direction in oblique cutting. A deviation is found from Stabler's rule of angle-of-chip flow being equal to angle of inclination.

Sample calculations of angle of inclination, normal and effective rake angles for lathe tools, milling cutters, and drills are given. Additionally, effect of web thickness, helix angle, and point angle on angle of inclination, normal and effective rakes is discussed.

Authors have condensed in one paper material that could have been more advantageously presented in a series of papers.

M. Martellotti, USA

1836. **Motherwell, G. W., Douslin, J. R., and Rustay, A. L., Large forging-press operations and production problems,** *Trans. ASME* **75,** 8, 1519–1523, Nov. 1953.

Examples of forging-design problems and progress are shown and discussed, illustrating recent advancements in the production of forgings with tin webs, smaller fillet and corner radii, and closer tolerances. Advancements in manufacturing techniques are described, including new processing methods and equipment. Factors affecting procurement time and cost are discussed.

From authors' summary by L. V. Colwell, USA

1837. **Stone, M. D., Design and construction of large forging and extrusion presses for light metals,** *Trans. ASME* **75,** 8, 1493–1512, Nov. 1953.

This paper gives a comprehensive review of the forging and extrusion processes leading up to and including a concise discussion of the problems associated with the design and construction of large presses for light metals. The development of forging and extrusion presses is traced from early history up to the present. Particular emphasis is placed on the design, construction, and maintenance problems associated with the very large forging and extrusion presses required for the magnesium and aluminum products used in military aircraft. Engineers and metallurgists will be particularly interested in the numerous equations and other technical information given in regard to forging loads and pressures as related to friction and the physical properties of both the work material and the die material. L. V. Colwell, USA

1838. **Fritzlen, T. L., Metallurgy and production of suitable aluminum-alloy ingots for large forgings and extrusions,** *Trans. ASME* **75,** 8, 1513–1518, Nov. 1953.

The sizes of 14S, 24S, and 75S aluminum-alloy ingots needed for the United States Air Force large-press program are estimated and compared to the size of ingots cast in current production. The direct-chill process is selected for development of the casting of large ingots. Quality required, metallurgical factors involved, equipment used, and casting variables are discussed. Experimental results in casting 14S aluminum-alloy ingots weighing up to 12,000 lb are presented. An opinion is expressed on the future production of large aluminum-alloy ingots for use in extrusion and forging presses up to 25,000 and 50,000 tons capacity, respectively. From author's summary by L. V. Colwell, USA

1839. **Khusid, S. D., A study of reduction by roller mills,** Nat. Sci. Found. tr-22, July 1953; *Dokladi Akad. Nauk SSSR* (*N.S.*) **88,** 3, 449–452, Jan. 1953.

1840. **Gubkin, S. I., and Muras, V. S., Electrolytic heating as a means of improvement of drawing processes** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **91,** 4, 803–806, Aug. 1953.

Authors claim to save time by eliminating furnace anneals and permitting greater reductions in cross-sectioned area per pass during the drawing of wire with the use of an electrolytic bath or two placed along the path of travel of the wire. Copper by this continuous method of electrolytic bright anneal and drawing was reduced in two passes to a cross section requiring five to six passes by the usual method. Copper required three passes and platinum two passes to be reduced 89–90% in cross-sectioned area.

Description of the method employed is incomplete. No operating current or voltage is given nor any illustrations of the apparatus. One should note that the materials used in this study, copper, platinum, aluminum, and steel, lend themselves fairly easily to drawing. Anna M. Turkalo, USA

1841. Colwell, L. V., and McKee, R. E., Evaluation of bandsaw performance, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-165, 16 pp.

Bandsawing of titanium alloys and SAE 1045 steel at various feeds and speeds is described. Tool forces are measured with a two-component dynamometer and recorded by oscillograph. The cutting force is approximately twice the feeding force when bandsawing steel, while these two force components are equal for commercially pure titanium; for titanium alloys the feeding force is greater than the cutting force. The relationship between cutting speed and tool life in bandsawing is expressed by an exponential equation of the same magnitude as that for turning.

A. O. Schmidt, USA

1842. Eisele, P. T., and Griffin, R. F., Some vibration effects on surfaces produced by turret lathes, *Trans. ASME* **75,** 7, 1211–1217, Oct. 1953.

Authors describe experimental investigation and give simple analysis of spiral patterns of surface irregularities produced on turned surfaces by vibration of cutting tool due to unbalance of rotating machine parts or similar sources. Patterns produced by unbalance of known frequency and magnitude are analyzed to show the relation of appearance and surface roughness to these quantities. Brief discussion is also included on the degree of balance obtained in commercial electric motors and its relation to the problem.

M. E. Merchant, USA

Hydraulics; Cavitation; Transport

(See also Revs. 1715, 1762, 1781, 1923)

1843. Keifer, C. J., and Chu, H. H., Backwater functions by numerical integration, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 383, 14 pp., Jan. 1954.

Many methods are known for backwater computation in regular open channels of various shape. However, they cannot be used in closed conduits when flow is near the top. Authors integrate equation of nonuniform flow in circular conduit in terms of the relative depth y/D and of the ratio α between given discharge and that for full capacity at the bottom slope. Computation of the backwater curve in a circular pipe laid on positive slope is considerably simplified by use of the tables for two backwater functions, which authors have prepared and presented in the Proceedings, regrettably in condensed form. Diagram is given also for use in the step method of constructing the surface profile. Similar method can be applied for other cross sections and slopes; special tables are necessary for each case. Paper is of value for sewer and culvert design.

S. Kolupaila, USA

1844. Schönfeld, F. C., Friction and resistance formulas for conduits and channels (in Dutch), *Ingenieur* 65, 45, 47; B.219–B.226, B.244–B.249, Nov. 1953.

Logarithmic friction formulas, according to the theoretical and experimental developments of von Kármán, Prandtl, and Nikuradse, are described in detail for practical purposes. In several American publications [see, e.g., AMR **4,** Rev. 1221] the same tendency is apparent to replace Manning's formula by the logarithmic one.

The effect of the shape of the cross section is approximated with sufficient accuracy.

Author makes a distinction between friction and resistance when dealing with irregularly shaped channels. For computations, also in treating unsteady flow, the use of characteristic quantities as conveyance and deliverance, as well as resistance, is suggested.

H. J. Shoemaker, Holland

1845. Climie, H. R., Flow in open channels, *Civ. Engng. Lond.* **48,** 569, 1039–1042, Nov. 1953.

Author simplifies the differential equation for surface profile in open-channel flow by making reasonable approximations. Equation is then integrated using a normalized velocity rather than a normalized depth as the independent variable. Method is limited to subcritical flow and to the assumption that the "cube root of mean-cube-velocity/average is unity except near the critical depth." Reviewer integrated the differential equation without these restrictions [*Trans. Amer. Soc. civ. Engrs.* **108,** p. 481] and results should be compared.

D. F. Gunder, USA

1846. Silvester, R., Flow in open channels, *J. Instn. Engrs. Austral.* **25,** 9, 155–162, Sept. 1953.

Author gives the equations for flow in a channel for the cases of uniform flow and nonuniform flow. He proposes very simple expressions of Manning's formula (uniform flow) and of the equation of variable motion, with an interpretation of the latter. In accordance with the various sections of the channels considered, diagrams are deduced from these relations. They indicate the values of Manning's coefficients as a function of the water depth and of a characteristic dimension (base width or top width). Adding a nomograph introduces the possibility of resolving the equations of nonuniform flow.

Knowing the main characteristics of the channel, it is possible to rapidly calculate the water depths for an uniform flow, a jump, etc.

L. Escande, France

1847. Synge, J. L., Flow of viscous liquid through pipes and channels, "Fluid Dynamics," Proc. Symp. appl. Math., vol. IV, New York, McGraw-Hill Book Co., Inc., 141–165, 1953.

Solutions of potential problems with mixed Dirichlet and Newman boundary conditions are found by a geometrical method in function space. The problems are first reduced to homogeneous form by the introduction of suitable particular solutions. With homogeneous boundary conditions, irrotational vector fields are orthogonal to solenoidal ones in the function space, which has as metric the integral of the square of the vector over the domain. These two orthogonal subspaces are positioned relative to the origin by the vectors representing the particular solutions. The intersection of the two subspaces yields the required harmonic solution.

This solution can be approximated in the mean square sense by choosing a finite number of function vectors in each subspace and taking the mean of the points of closest approach of the two finite linear subspaces which they span. The mean square error is then half the metric distance between the points of closest approach. Suitable function vectors are provided by pyramid functions. These vanish outside a closed polygon, behave simply within, and, according as they are irrotational or solenoidal, have vanishing tangential or normal components on the boundary. If the domain is triangulated with sufficient fineness, either type of field may be approximated arbitrarily closely by a linear function of these pyramid functions.

Three numerical examples are given. The first is flow under pressure along a pipe of hexagonal cross section. The second is flow with drag along a channel of square cross section, and the last treats the same problem for an irregular cross section. In each case, numerical bounds for the Dirichlet integral are given so that the discharge of the pipe or the work done by the drag forces can be estimated.

A. F. Pillow, Australia

1848. Schwarz, G. M., Determination of economical tube diameter in distant heating pipe lines (in German), *Brennstoff-Wärme-Kraft* **6,** 1, 7–9, Jan. 1954.

1849. **Nagai, S., On the two-dimensional analyses of suddenly contracted flows,** *J. Japan Soc. appl. Mech.* **5,** 30–31, 156–158, Dec. 1952–Jan. 1953.

Position of contraction in suddenly contracted flows is determined by use of the Schwarz-Christoffel theorem. Study is made for flows about a suddenly contracted pipe and about that having a round corner. The position of contraction is approximately given with determination of the stationary points of vortex center. Corner radius can be found by which vortex will vanish.

F. Keune, Sweden

1850. **Frank, O. J., Rythmical closing and opening of turbine gates and the calculation of the surges in surge tanks** (in German), *Wasserwirtshaft* **44,** 1, 18–21, Oct. 1953.

Paper deals with rythmical movements of turbine gates and the surges they cause in surge tanks when load is successively thrown on and then off, or off and on again. The final surge in the surge shaft is greater than for ordinary closing or opening movement of the turbine gates. The surges are greatest if the gate movement occurs when the velocity in the tunnel is maximum. Author produces two diagrams summarizing the results of his calculations over a wide range of power stations and surge tanks.

C. Jaeger, England

1851. **Boudan, J., Instruments for the measurement of rapidly varying levels on hydraulic models** (in French and English), *Houille blanche* **8,** 4, 541–545 (French text, 526–540), Aug.-Sept. 1953.

Author discusses the instruments developed and used for this purpose by the Laboratoire Dauphinois d'Hydraulique. The sensing elements are of the capacity type. Enameled copper wire is tightly strung on a frame, the enamel serving as the dielectric between the water and wire. For the wave recorder, "the range of measurable amplitudes is included between 50 cm and $^1/_2$ mm" with an accuracy "often as high as 1% for periods greater than 0.6 sec." Article is descriptive only. No design information is given.

H. G. Farmer, Jr., USA

1852. **Barbe, R., and Beaudevin C., Experimental research on the stability of a rubble mound breakwater subjected to wave action** (in French), *Houille blanche* **8,** 3, 346–359, June-July 1953.

1853. **Labaye, G., and Duranton, R., Use of subterranean tunnels as compensating reservoirs** (in French), *Houille blanche* **8,** B, 735–746, Nov. 1953.

Subterranean tunnels can be used as compensating reservoirs during periods of low water. What is the volume usable in practice? At peak periods the turbine discharge is much higher than the inflowing discharge and, by discharging, the water in the tunnel progressively reaches a state of free surface flow. The time comes when critical regime is reached in the downstream section and, at this moment, the water-level profile determines the unusable residual volume.

A graphical study of the water-level profiles is given here in accordance with methods derived from Saint Venant and Craya for the initial state and the variable regime, respectively.

From authors' summary

1854. **Mathieson, R., Reservoir regulation problems,** *Proc. Instn. civ. Engrs.* **2,** 2, 311–326, Aug. 1953.

1855. **Hee, A., and Keller, P., Application of radioactivity in fluid-flow investigations** (in French), *C. R. Acad. Sci. Paris* **238,** 1, 44–46, Jan. 1954.

Incompressible Flow: Laminar; Viscous

(See also Revs. 1849, 1917, 2036)

1856. **John, F., Two-dimensional potential flows with a free boundary,** *Comm. pure appl. Math.* **6,** 4, 497–503, Nov. 1953.

Inverse method is described for solving problems of steady and unsteady two-dimensional incompressible free surface flows with gravity present. Let w denote the Lagrange coordinate for particles on the free boundary, t the time, $z = f(w, t)$ the complex position vector, $r(w, t)$ a real function, and $F(w, t)$ the complex velocity potential. Then $f_{tt} + ig = ir(w, t)f_w$ is the free surface condition and F can be found from $F_w(w, t) = f_t(\bar{w}, t)f_w(w, t)$. As a special case, the most general *steady* flow is established by the surface condition $p''(W) + ig = is'(W)p'(W)$ and the corresponding equation for the velocity potential becomes $dF/dW = \overline{p'(\bar{W})}p'(W)$, where $W = w + t$, $s' = r$, and $p = f$. Interesting examples given are $s = \text{const } W$ for the steady case (which is modified by introducing a moving coordinate system to obtain progressive wave motion), and $r = 1$ for the unsteady case.

V. G. Szebehely, USA

1857. **Nekrasov, K. P., Movement of a cylindrical body in a fluid, according to the theory of diminishing viscosity** (**two-dimensional steady flow**) (in Russian), *Prikl. Mat. Mekh.* **17,** 1, 17–32, Jan.-Feb. 1953.

Boundary-layer theory treats only the flow within the boundary layer and determines the points where the boundary layer separates itself from the surface of the obstacle. Boundary-layer theory does not treat the influence of the formation of vorticity, which is secondarily connected with separation of the boundary layer, on the distribution of velocities and pressures outside the boundary layer. The problem of determining the drag and flow around obstacles is, therefore, associated with this problem which is not yet definitely resolved. It can only be resolved by finding the complete solution to the boundary-value problem.

The well-known Oseen solution contains an indefinitely strong vorticity at the boundaries at the wake, which is straight and touches the body tangentially. Zeilon has improved on this disadvantage of Oseen's solution by suppositions which are not entirely acceptable from the hydrodynamic point of view.

In the present report, author determines the drag and flow around an indefinitely long cylindrical body that moves uniformly in a liquid with small viscosity; the direction of motion is perpendicular to the body of axis. No assumptions are made beyond those of small fluid viscosity and weak vorticity in the general stream. The wake (as in both the work of Oseen and Zeilon) will be bounded by two rectilinear semi-infinite planes tangential to the body and parallel to the direction of motion. But the vorticity has definite values not only in the wake but also in its boundary regions. By considering the appropriate boundary conditions, the problem is reduced to the solution of an integral equation with a Cauchy-type kernel.

The drag of a circular cylinder is determined on the basis of the author's solution. This has the value $C_D = 1.137$, which corresponds with experimental results when $Re = 560$ and $Re = 10^4$. The calculated value differs from the experimental values in the interval between these Re numbers by approximately 0.07. It is to be noted that this value of drag coefficient (1.137) is between the values which Oseen (1.314) and Zeilon (0.480 and 0.523) have calculated.

M. Strscheletzky, Germany

1858. **Davies, T. V., The forced flow of a rotating viscous liquid which is heated from below,** *Phil. Trans. roy. Soc. Lond.* (*A*) **246,** 907, 81–112, June 1953.

Experiments were conducted at the University of Chicago (by

Fultz, 1951) with a cylindrical vessel filled with water and heated at the horizontal base. The heating was approximately symmetrical about the central point of the base, with differences in temperature between the wall and the center of the vessel of 5 to 15 C. Vessel was subjected to various rates of rotation about its central axis.

Two principal régimes have emerged, which are referred to as the low- and high-rotation cases. In the former, the motion of the free surface is predominantly symmetrical about the central axis, and any variations in the transverse directions are small. In the latter, the motion is marked asymmetrical in character, consisting of distinct finite-amplitude wave patterns in the transverse direction. The experiments acquire considerable interest for the similarities between the high-rotation régime and observed flows of the earth atmosphere.

In the present paper, author discusses only the symmetrical forced flow, in three successive steps.

1 Given the equations of fluid dynamics (with variable density, variable temperature, and utilization of the equation for heat transfer), author studies the fluid movement with zero rotation, no variation in time, no angular variation, no nonlinear terms. With these limitations an exact solution is given; then an approximate method is described which is verified to the stated order. With this method, author shows: (a) An exact correlation between the vertical velocity w and the heating function on the base. Hence, as much heat is removed at the base as enters. (b) The vertical velocity attains a maximum value at $z = 0.6h$ (h is height of the water in the vessel); the radial velocity attains a maximum value at $z = 0.25h$, a zero at $z = 0.6h$, and a minimum value at the free surface. (c) The viscous conditions on the side of the vessel are unimportant in the problem.

2 In the second step, author studies steady symmetrical solutions with rotation Ω, heating, and without nonlinear terms. He introduces an important Reynolds number $R = \Omega\rho_0 h^2/\mu$ (ρ_0 initial density, μ viscosity) and the root $\omega = R^{1/2}$. Using the same approximate method as in (1), author shows (a) that w decreases with increasing Ω and, when Ω becomes sufficiently large, the vertical velocity w tends to assume a constant value (apart from the boundaries where w is zero). (b) When Ω increases, the radial velocity u decreases rapidly. For large ω, $u(\xi) \sim \exp(-\omega\xi)$; ($\xi = z/h$; $0 < \xi < 1$). (c) The zonal velocity v increases with Ω for small values of ω; and for large values of R the flow tends to become a uniform shearing flow with a maximum at the free surface. Here also, however, v tends to zero when $\omega \to \infty$. Thus when Ω is sufficiently great the fluid is essentially in solid rotation.

3 The last step was to study the effect of nonlinear terms. Since the inertia forms are nonlinear and their influence is difficult to assess, it is proposed to investigate three nonlinear terms only, and to investigate them separately. Terms considered are $w(\partial v/\partial z)$, $(u/r)(\partial/\partial r)(vr)$, and v^2/r. G. Supino, Italy

1859. Kronig, R., On the hydrodynamics of non-viscous fluids and the theory of helium II. Part III, *Physica* **19**, 6, 535-544, June 1953.

1860. Valensi, J., and Clarion, C., Oscillatory movement of fluid with viscosity and inertia; case of finite amplitudes (in French), *C. R. Acad. Sci. Paris* **237**, 19, 1138-1140, Nov. 1953.

For calculating the oscillations with finite amplitude x of a fluid column (length L, radius R, density ρ, viscosity ν), author proposes the nonlinear differential equation

$$a_3(d^2x/dt^2) + a_1(dx/dt) + a_2(dx/dt)|(dx/dt)| + x = 0$$

where the third member considers the turbulent friction in the boundary layer. Equation is derived on semiempirical basis; the coefficients a_n are functions of L, R, ρ, and g. Solutions by numerical integration are given for some a_n-values.

Margot Herbeck, Germany

1861. Fox, J. L., and Morgan, G. W., On the stability of some flows of an ideal fluid with free surfaces, *Quart. appl. Math.* **11**, 4, 439-456, Jan. 1954.

Authors discuss the stability of the following inviscid incompressible two-dimensional flows under no forces: (1) A jet of finite width impinging on a plate; (2) equal and opposite impinging jets; (3) a mouthpiece of angle $2\pi/n$, n an integer; (4) a hollow vortex. The conclusions are that (1) is neutrally stable or stable, (2) has a range of unstable perturbations, (3) is stable except for $n = 1$ (Borda's mouthpiece), for which there exists an isolated unstable perturbation, and (4) is stable. The paper contains several misprints. L. M. Milne-Thomson, England

1862. Collins, R. E., Calculations of unsteady-state gas flow through porous media, corrected for Klinkenberg effect, *J. Petr. Technol.* **5**, 12, 19-20, Dec. 1953.

Mathematical equations are derived to show the effect of gas-slip phenomenon on unsteady-state gas flow through porous media. The assumption is made that the slippage may be represented by an equation of the type $k = a(1 + b/p)$, where k is the permeability, p pressure, and a and b are constants. It is pointed out that the resulting differential equation, which accounts for gas-slip effects, can be transformed into the same form that previously has been presented as representative of unsteady-state gas flow where gas-slip effects are neglected. For more detailed information on this subject, reader is referred to an article by J. S. Aronofsky [*J. appl. Phys.* **25**, no. 1, 1954].

J. S. Aronofsky, USA

1863. Coffee, C. W., Jr., and McKann, R. E., Hydrodynamic drag of 12- and 21-per cent-thick surface-piercing struts, *NACA TN* 3092, 28 pp., Dec. 1953.

An investigation has been made to determine the hydrodynamic drag of three surface-piercing untapered struts at approximately 0° angle of yaw at depths up to 6 chords for speeds up to 80 fps at various angles of rake. Two struts had NACA 66_1-012 airfoil sections, one with a 4-in. chord and the other with an 8-in. chord. The third strut had an NACA 66_4-021 airfoil section and a 4-in. chord. From authors' summary

1864. Neumark, S., and Collingbourne, J., Velocity distribution on untapered sheared and swept-back wings of small thickness and finite aspect ratio at zero incidence, *Aero. Res. Counc. Lond. Rep. Mem.* 2717, 50 pp., Mar. 1949, published 1953.

This report is a continuation of AMR **6**, Rev. 1691 and gives several new solutions of the velocity distribution on finite and semi-infinite sheared and sweptback wings. The treatment is restricted to untapered wings at zero incidence.

As in the previous report, the solutions are based on a first-order method, using source-sink distributions. The validity of this method near the tips and the kink of a thin swept wing is discussed in detail and it is shown that there are only small discrepancies in very narrow marginal strips which have no practical significance.

The velocity distribution is determined for (1) semi-infinite sheared and straight wings and (2) finite sheared and straight wings with biconvex parabolic airfoil sections. The velocity distribution at the tip of the semi-infinite sheared wing is quite different from that near the kink section of a sweptback wing,

the maximum supervelocity at the tip being half that for the center section of a sweptback wing.

For a finite sheared wing with biconvex parabolic profile at zero incidence, the entire supervelocity distribution is symmetrical with respect to the mean chord of the wing, the supervelocity distributions in any two sections parallel to this chord and equidistant from it being identical but reversed. The maximum supervelocity occurs at the mean chord of the wing where the flow is practically the same as that for an infinite sheared wing, provided the sweepback is not too large or the aspect ratio too small.

The method is extended to wings with arbitrary profiles (with certain restrictions on sections with rounded noses) and the supervelocity distribution is determined at the tip and center of a finite sheared wing. Finally, by combining two sheared wings the velocity distribution on finite sweptback wings is determined. For such wings the isobars over most of the wing are practically the same as those over an infinite sheared wing; those over the center kink are very similar to the corresponding isobars for an infinite sweptback wing, while those at the tips are similar to the isobars obtained for semi-infinite sheared wings. It is found that, contrary to Ludwieg's assertion [British Reports and Translations 84], reducing the aspect ratio may cause the maximum supervelocity to increase slightly if the angle of sweepback is large.

The drag distribution is calculated for the case of a biconvex parabolic profile and it is found that, while the total potential drag is zero for a finite wing, it differs from zero for infinite or semi-infinite wings. A. W. Babister, Scotland

Compressible Flow, Gas Dynamics

(See also Revs. 1880, 1881, 1928, 1955)

1865. **McVittie, G. C., Spherically symmetric solutions of the equations of gas dynamics,** *Proc. roy. Soc. Lond.* (*A*) **220**, 1142, 339–355, Dec. 1953.

In the case of a spherically symmetric motion of any gas, it is shown that radial velocity, density, and pressure can be expressed in terms of an arbitrary scalar function. In progressing waves, this function is assumed to be a product of an arbitrary function of time t and an arbitrary function of a parameter $rt - \alpha$, r and α being, respectively, the radial distance and a constant. Detailed study of all possible isentropic and nonisentropic motions has been carried out for cases where the radial velocity is proportional to r. Due to this assumption, the solutions discovered by G. I. Taylor [title source, (*A*) **201**, 159–186, 1950] and G. Guderley [*Luftfahrtforsch.* **19**, 302–312, 1942] are excluded from the family of solutions thereof. Y. H. Kuo, USA

1866. **Sauer, R., Hyperbolic problem in gas dynamics with more than two independent variables** (in German), *ZAMM* **33**, 10/11, 331–336, Oct./Nov. 1953.

Paper presents a systematic review of the mathematical methods applied to compressible flow problems involving more than two independent variables (nonsteady two-dimensional flow, steady or nonsteady three-dimensional flow). The review is restricted to problems of the hyperbolic type for nonviscous flows. Nonlinear methods are also discussed.

S. Ostrach, USA

1867. **Krzywoblocki, M. Z. e., Bergman's linear integral operator method in the theory of compressible fluid flow,** *Öst. Ing.-Arch.* **7**, 4, 336–370, 1953.

In this second part of his work on Bergman's linear integral operator method, the author discusses supersonic and transonic flow. At first, the operator obtained by the use of Riemann's function is thoroughly discussed, as well as the question of the domain of convergence. In the section on transonic flow, the application of the integral operators of the first and second kind in the case of the exact and the simplified compressibility equation is shown. From author's summary

1868. **Fraenkel, L. E., On the operational form of the linearized equation of supersonic flow,** *J. aero. Sci.* **20**, 9, 647–648, Sept. 1953.

In this Readers' Forum note, author presents a more rigorous derivation of the operational (Laplace transform) form of the linearized equation for supersonic flow, accounting for discontinuous derivatives of the perturbation potential.

H. N. Abramson, USA

1869. **Rosenbloom, P. C., The linearized theory of supersonic flow about a thin airfoil,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 319–334, 1953.

This 1946 paper derives the basic integral equation of planar problems in steady linearized supersonic flow without subsonic trailing edges (*V* domains). Divergent integrals in the application of Green's theorem are avoided by M. Riesz's method of analytic continuation. Well-known explicit solutions for the symmetric wing are given. (Pages 312–323 are interchanged.)

M. V. Morkovin, USA

1870. **Sherman, F. S., New experiments on impact-pressure interpretation in supersonic and subsonic rarefied gas streams,** *NACA TN* 2995, 73 pp., Sept. 1953.

Note discusses impact-pressure experiments conducted since original tests and reported earlier [AMR **4**, Rev. 1335; Univ. of Calif. Rep. no. HE-150-82, March 1951]. Additional data on viscous effects are presented for Mach number ranges of 0.1 to 0.7 and 1.7 to 3.4, while Reynolds number (based on impact probe size) is varied from 2 to 800.

Method of attacking problem involved performance comparisons of probes of different diameters and "extrapolaton technique" originally applied in latter reference. In addition, three different probe tip geometries were tested and the resulting impact-pressure correction factors plotted. Reynolds number 200 appears to be critical for supersonic flow, since measurement at larger values required negligible correction.

Appendixes describe an especially accurate McLeod gage, a remote indexing mechanism for selecting any of several probes, and a new wind-tunnel nozzle producing "isentropic core."

Reviewer believes that paper is an important contribution to field of interpreting impact-pressure readings. Since readings from probes of small diameters, i.e., small Reynolds numbers, require some viscous correction, it is felt that this work will be of especial importance to boundary-layer researchers employing impact probe techniques. H. L. Bloom, USA

1871. **Fraenkel, L. E., Curves for estimating the wave drag of some bodies of revolution, based on exact and approximate theories,** *Aero. Res. Counc. Lond. curr. Pap.* 136, 15 pp., Aug. 1952, published 1953.

Curves are presented for estimating the wave drag, at zero incidence, of forebodies and afterbodies having straight and parabolic profiles. The afterbodies are assumed to lie behind an infinitely long cylindrical body. The curves are based on a limited number of exact and second-order solutions which have been generalized by appealing to the supersonic-hypersonic similarity law and to slender body and quasi-cylinder solutions.

From author's summary

1872. Relf, E. F., Note on the lift slope, and some other properties, of delta and swept-back wings, *Aero. Res. Counc. Lond. curr. Pap.* 127, 9 pp., June 1952, published 1953.

1873. Michel, R., Marchaud, F., and Le Gallo, J., Study of transonic flow around lenticular airfoils at zero angle of attack (in French), *ONERA Publ.* 65, 27 pp., 1953.

Paper presents results of interesting tests in transonic Chalais-Meudon wind tunnel of semi and full lenticular airfoil section at zero angle of attack for Mach numbers of 0.7 to 1.1. In the first part the following items are investigated: Influence of the nature of boundary layer on velocity distribution; comparison with Liepmann's tests (*USAF, TR* 5667, Feb. 1948), where a satisfactory agreement is found; local supersonic-flow régime without shocks for Mach numbers of incoming flow from 0.75 to 0.86, and with shocks; values of critical Mach number calculated by means of Prandtl-Glauert, von Kármán-Tsien, and Temple formulas are compared with test data. In the second part, authors compare test data with von Kármán similarity rule and Gullstrand theory, obtaining confirmation of these analytic approaches. M. Z. Krzywoblocki, USA

1874. Bergdolt, V. E., Airflow about cone-cylinders with curved shock waves, *J. aero. Sci.* **20**, 11, 751–756, Nov. 1953.

Flows about 35° cone cylinders in free flight at Mach numbers, ranging from the régime of detached shocks to the establishment of completely supersonic Taylor-Maccoll flow, are investigated with interferometric techniques. Good agreement is found when the density and pressure distributions (obtained from measured fringe shifts) are compared with theoretical predictions and wind-tunnel data.

From author's summary by F. A. Goldsworthy, England

1875. Konzo, S., Gilman, S. F., Holl, J. W., and Martin, R. J., Investigation of the pressure losses of takeoffs for extended-plenum type air conditioning duct systems, *Univ. Ill. Engng. Exp. Sta. Bull.* ser. no. 415, 54 pp., Aug. 1953.

Authors attempt to study the following problems: (1) To determine shapes of take-offs (in ducting) which would give good performance and be simple in construction; (2) to determine the performance of several sizes of standard side and top take-offs installed on larger extended plenums than previously used; (3) to study the effect of the relative locations of two or more take-offs on the pressure losses of individual take-offs.

The results indicated: (1) That the pressure losses of all take-offs were found to be a function only of the ratio of the velocity in the branch duct to the velocity in the plenum just upstream of the take-off; (2) that the pressure losses of standard take-offs did not depend upon the size and shape of the extended plenum; (3) that the performance of a given take-off was not affected by the relative locations of other take-offs.

Practical interpretations of the results as well as pressure-loss curves for design purposes are presented in the paper.

Y. S. Touloukian, USA

1876. Miles, J. W., On the low aspect ratio oscillating rectangular wing in supersonic flow, *Aero. Quart.* **4**, part 3, 231–244, Aug. 1953.

Laplace transform in terms of Mathieu functions of general solution of linearized problem of oscillating rectangular wing in supersonic flow is established by separation of variables in elliptic coordinates. Results are expanded for case of no spanwise distortion into powers of aspect ratio in order to compare with slender-body theory. Stability derivatives are calculated and single-degree-of-freedom instability in pitch is shown to be impossible to approximation neglecting fourth power of aspect ratio.

J. H. Greidanus, Holland

1877. Pack, D. C., A note on the unsteady motion of a compressible fluid, *Proc. Camb. phil. Soc.* **49**, part 3, 493–497, July 1953.

It is well known that the solution of the differential equations of nonsteady one-dimensional flow of an ideal inviscid and isentropic gas can be given in closed form if the ratio γ of the specific heats satisfies the condition $\gamma = (2m + 3)/(2m + 1)$, m being a nonnegative integer. The solution contains two arbitrary functions $F_1(r)$ and $F_2(s)$, where r and s are the characteristic variables, and also derivatives of F_1 and F_2 up to the order $(2m - 1)$. Generally, it is very difficult or practically impossible to determine these two functions from given initial and boundary conditions (e.g., see the cumbersome formulas of Love and Pidduck dealing with Lagrange's problem in internal ballistics, *Phil. Trans. roy. Soc. Lond.* (*A*)**222**, 167–226, 1922). In the present paper, author succeeds in determining the two functions in the case $m = 1$ ($\gamma = 5/3$) for the following initial value problem: The gas being in rest at the time $t = 0$ is bounded by vacuum. The temperature distribution at $t = 0$ is specified by the condition that the characteristic variable r increases from $r = 0$ at the surface of the gas proportionally with the distance x from the surface up to a constant final value. As a result, the characteristics r = const in the x, t-plane converge to a point $x = 0$, $t = t_e$. The surface of the gas does not move until $t = t_e$; at later times $t > t_e$ the front moves with uniform velocity and is followed by a simple wave. Application: Study of interstellar gas clouds.

Courtesy Zentralblatt f. Mathematik R. Sauer, Germany

1878. Siestrunck, R., Fabri, J., and Le Grives, E., Some properties of stationary detonation waves, Fourth Symp. (International) on Combustion, 498–501, 1953; Baltimore, Md., Williams and Wilkins. Co.

Polar curves, similar to those for shock waves, are shown to exist for oblique stationary detonation waves. It is shown that the significant branch of the detonation polar is a closed curve lying inside the corresponding shock polar. As for shock waves, a strong and weak oblique detonation is found. Because the characteristic lines in the flow downstream of the weak detonation do not intersect it, authors believe that weak normal detonations are impossible. J. A. Fay, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 1954, 1955, 1959, 2037)

1879. Diessler, R. G., Heat transfer and fluid friction for fully developed turbulent flow of air and supercritical water with variable fluid properties, *Trans. ASME* **76**, 1, 73–83, Jan. 1954.

Paper extends analysis previously given by author [AMR **4**, Rev. 3643] for a fluid of Prandtl number 1 to air (Prandtl number 0.73), and to supercritical water. The results are correlated in terms of a suitable reference temperature at which the variable fluid properties are evaluated. Experimental data for air in turbulent motion in a smooth tube with heat transfer at large temperature differences are included and compared with analytical results. Good agreement was obtained for Reynolds numbers above 15,000. H. L. Dryden, USA

1880. Lange, A. H., and Lee, R. E., Note on boundary-layer transition in supersonic flow, *J. aero. Sci.* **21**, 1, p. 58, Jan. 1954.

Tests have been made in the Naval Ordnance Laboratory 40 ×

40-cm aeroballistics wind tunnel with two hollow cylinders, each with its axis of revolution in the stream direction and operating under swallowed shock conditions. One cylinder had an inside bevel at the leading edge and the second had an outside bevel. The presence of the small pressure gradient in the second case provided a stabilizing influence sufficient to delay the transition from laminar to turbulent boundary layer on the outer surface of the cylinder. At $M = 2.5$ the laminar boundary layer on the model with the outside bevel was extended by about 50% over that on the other model and by about 66% at $M = 3.25$. Further tests are planned in which the bevel angle will be varied while the frustrum length is held constant. By such changes in pressure gradient, the skin friction drag and aerodynamic heating on the nose of a missile might be reduced.

Ione D. V. Faro, USA

1881. **Harrin, E. N., A flight investigation of laminar and turbulent boundary layers passing through shock waves at full-scale Reynolds numbers,** *NACA TN* 3056, 20 pp., Dec. 1953.

An investigation was made in flight at free-stream Mach numbers up to about 0.76 and Reynolds numbers up to about 26×10^6 to determine the behavior of laminar and turbulent boundary layers passing through shock waves. Boundary-layer and pressure-distribution measurements were made on a short-span airfoil built around a wing of a fighter airplane. The free-stream Mach numbers reached in the tests were sufficiently high to give extensive regions of local supersonic flow. Comparison is made with results of tests at low Reynolds numbers (up to $^1/_{10}$-scale) of other investigations.

From author's summary

1882. **Gontier, G., and Martinot-Lagarde, A., Boundary-layer velocity profile along a plane surface in a compressible fluid** (in French), *C. R. Acad. Sci. Paris* **237**, 18, 1062–1064, Nov. 1953.

The velocity profiles in a turbulent boundary layer are measured for $M_0 \leq 0.8$. The local Mach number M underwent small variations $-0.025 < (x/M_0)(dM/dx) < 0.025$. The experiments show that the velocity profiles practically coincide with those for $M_0 = 0$.

I. Flügge-Lotz, USA

1883. **Rashis, B., An analytical investigation of the effect of the rate of increase of turbulent kinetic energy in the stream direction on the development of turbulent boundary layers in adverse pressure gradients,** *NACA TN* 3049, 30 pp., Nov. 1953.

A general derivation is presented for momentum, kinetic energy, and higher-order equations for turbulent boundary layers. Reynolds normal stress, that part of Reynolds stress due to intensity of turbulence, is included. Using the idea of Taylor for effect of stream contraction on turbulence, author derives an expression relating turbulence intensity to local mean velocity and upstream reference conditions. When applied to data of Schubauer and Klebanoff [*NACA Rep.* 1030], resulting agreement of momentum equation is no better than that obtained with other assumptions. A discussion of parameters for dissipation of mean-flow kinetic energy is also included.

Reviewer finds paper rather disjointed and lacking in positive conclusions, so does not believe it will have wide circulation among engineers.

W. D. Baines, Canada

1884. **Truckenbrodt, E., Flow around rotating bodies with flow direction parallel to the axis of rotation** (in German), *ZAMM* 33, 8/9, 311–312, Aug./Sept. 1953.

Paper is a summary of work to be published. Momentum equations for the boundary layer on rotating bodies of revolution with flow directions parallel to the axis of revolution have been derived. With the help of a law for the wall stress, the momentum equation in the azimuthal direction can be simplified to a simple integration formula to calculate the torque. The formula contains only the distribution of the radius of the body and the potential velocity distribution along a meridian. There are slightly different forms for laminar and turbulent boundary layers. A diagram shows the torque coefficient as a function of *Re* for spheroids of different thickness ratios.

T. R. Gullstrand, Sweden

1885. **Chevallier, J. P., and Jousserandot, P., Application of injector for boundary-layer suction on an airplane wing** (in French), *Rech. aéro.* no. 35, 25–29, Sept.-Oct. 1953.

Author adopts one-dimensional incompressible theory to establish performance characteristics of an ejector as function of dimension parameters. Mixing zone is assumed cylindrical.

The title is misleading. The only connection with an airplane wing is the definition of several "coefficients of adaptation" and a weighting factor when using the ejector for boundary-layer control, namely, suction and activation by blowing.

Author talks rather freely of supersonic case, although the treatment is purely incompressible.

L. S. Dzung, Switzerland

1886. **Reichardt, H., Energy supply of boundary turbulence** (in German), *ZAMM* **33**, 10/11, 336–345, Oct./Nov. 1953.

Author expresses in somewhat more specific form than heretofore [see, e.g., the Bakhmeteff-Allan paper and discussions in *Trans. Amer. Soc. civ. Engrs.* **111**, 1946] relationships for the production, transfer, and dissipation of turbulence energy in uniform flow between plane boundaries. Distribution functions are formulated for the wall and central regions corresponding to those for the mean velocity.

H. Rouse, USA

1887. **Okabe, J., An approximate calculation of the laminar boundary layer of a flat plate of a constant breadth,** *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **2**, 6, 80–85, June 1953.

1888. **Rotta, J., Method of approximation for calculating boundary layers with aid of the energy law** (in German), *Mitt. Max-Planck-Inst. Strömungsforschung* no. 8, 51 pp., 6 figs., 1953.

Two methods for calculating turbulent boundary layers in two-dimensional and axial-symmetrical incompressible flow are described. Essential assumptions are: (1) Viscosity and roughness influence the boundary layer only within a partial layer with the thickness δ_a near the wall; (2) the outer part of the boundary-layer profile depends only on one parameter; (3) both parts overlap one another within a small region, where the known universal law is valid (which depends upon wall shearing stress and distance from the wall only); (4) there is a direct dependence between the boundary-layer profile and the distribution of statistical fluctuations.

Using the momentum and energy theorems, two ordinary differential equations of first order are derived and solved with the help of diagrams and nomograms (working sheets are given). The second method is approximate and integrates the momentum equation only and therefore is not as exact as the first mentioned. The advantage of these methods as against others is seen in the fact that the boundary-layer profile is given by two values: the usual form parameter H_{12} and the shearing stress at the wall c_f'. Therefore it is possible to investigate the flow along smooth as well as along rough walls. Separation is defined to be at that location where the wall shearing stress goes to zero. Some numerical examples are carried out and show good results compared with experiments.

F. W. Riegels, Germany

1889. Rotta, J. C., Similarity theory of isotropic turbulence, *J. aero. Sci.* **20,** 11, 769-778, 800, Nov. 1953.

Structure of turbulence changes during period of decay, but homogeneous isotropic turbulence decays toward a universal state independent of factors at its creation. Isotropic properties in the eventual universal state are described by a characteristic velocity and length (both functions of time) and the kinematic viscosity. Equation for the energy spectrum is derived and shown to have one distinct solution satisfying continuity in the range of smallest wave numbers—corresponding to the universal state. Experiments show this solution is satisfied best by $\xi = 5$, where $F(k, t) \propto k^{\xi-1}$ and where k is the wave number. Results of experiments behind grids agree with the theoretical frequency spectrum for $\xi = 5$, agreeing more closely as the universal state is approached at increasing distances from the grid.

L. M. Laushey, USA

1890. Bass, J., On the functional equations of turbulent flow (in French), *C. R. Acad. Sci. Paris* **237,** 13, 645-649, Sept. 1953.

Author establishes equations for determining the functional characteristic in spectral terms of an incompressible, turbulent flow field, obeying the Navier-Stokes equations, in space and space-time fields. Work complements and verifies the previous work of E. Hopf; author sets up the equations in a more direct fashion than previously by expressing the functional characteristic φ in terms of a Stieltjes integral, the random velocity V and the pressure P being expressed as Fourier stochastic integrals.

G. V. Bull, Canada

1891. Hohne, W., A thermoelectric turbulence measuring device (in German), *Z. Meteor.* **7,** 7, 215-218, July 1953.

This anemometer consists essentially of a heating and a measuring circuit containing a thermojunction and, in addition, an unheated thermocouple as reference point. To make the instrument less sensitive to spatial variations in air temperature the two elements are located as close to each other as is possible without giving rise to mutual thermal influences. The anemometer is said to make possible nearly true point measurements of the air velocity, whereas the normal hot-wire anemometer averages spatially along the wire. Measuring errors due to deviations of the air temperature from the calibration temperature are very small.

Reviewer is not convinced that the first statement is correct, because the temperature of the junction proper is certainly affected by spatial turbulence variations in air velocity along the wires of the thermojunction. Since, moreover, no data are given concerning the air velocity-thermovoltage characteristic, it is impossible to criticize the instrument as a turbulence anemometer.

J. O. Hinze, Holland

Aerodynamics of Flight; Wind Forces

(See also Revs. 1864, 1869, 1922, 1930)

1892. Cole, Isabella J., and Margolis, K., Span load distributions resulting from constant vertical acceleration for thin sweptback tapered wings with streamwise tips. Supersonic leading and trailing edges, *NACA TN* 3120, 62 pp., Jan. 1954.

On the basis of the linearized supersonic-flow theory, equations for the span-load distribution resulting from constant vertical acceleration (i.e., linear variation of angle of attack with time) are derived for a series of thin sweptback tapered wings with streamwise tips. The analysis is valid at Mach numbers for which the wing leading and trailing edges are supersonic. A minor restriction is that the Mach line from the leading edge of either wing tip may not intersect the remote half wing.

The computational results of the investigation are presented in a series of charts from which the span loadings may be obtained for given values of aspect ratio, taper ratio, leading-edge sweepback, and Mach number. For illustrative purposes, variations of the spanwise distribution of circulation (which is proportional to the span-load distribution) with several planform parameters and Mach number are shown, in addition to some typical chordwise and spanwise pressure distributions.

From authors' summary by T. R. Gullstrand, Sweden

1893. Anonymous, Aero-isoclinic wing and all-moving wing-tips, *Aircr. Engng.* **26,** 299, 18-20, Jan. 1954.

1894. Bleviss, Z. O., Some integrated properties of pressure fields about supersonic wings, *J. aero. Sci.* **20, 12,** 849-851, Dec. 1953.

Lagerstrom and Van Dyke [AMR **6,** Rev. 1949] have proved some remarkably simple theorems concerning the integrated properties of the linearized pressure fields on planar supersonic wings, subject to certain restrictions on the wing planforms. It has been found that similar properties exist for the pressure fields in certain planes about supersonic wings. The results are presented briefly, and one practical application is mentioned.

From author's summary

1895. Dannenberg, R. E., and Weiberg, J. A., Effect of type of porous surface and suction velocity distribution on the characteristics of a 10.5-percent-thick airfoil with area suction, *NACA TN* 3093, 59 pp., Dec. 1953.

Results are presented of an investigation of a two-dimensional, 10.51-per cent-thick symmetrical airfoil with area suction near the leading edge. Lift and suction-flow characteristics were determined with different porous surfaces (perforated plates and sintered steel) for various suction velocity distributions. The flow requirements were ascertained over a range of free-stream velocities. The maximum lift was independent of the surface of the materials tested.

From authors' summary

1896. Laidlaw, W. R., Spanwise and chordwise loadings for rectangular wings of aspect ratio near unity, *J. aero. Sci.* 20, 11, 783-785, Nov. 1953.

For the wings considered, the lifting-surface integral equation can be simplified because of the aspect ratio being near unity. An additional assumption of the pressure distribution, which does not provide for spanwise variation in section center of pressure, leads to reasonable solutions for total lift and pitching moment, spanwise and chordwise lift distribution, and approximate chordwise pressure distribution. For a flat plate wing at angle of attack with aspect ratios from $^1/_2$ to 2, the Fourier coefficients of this solution are tabulated. The effects of aspect ratio on lift-coefficient slope and center of pressure are shown. Results agree well with other theories.

H. P. Liepman, USA

1897. Nonweiler, T., The theoretical wave drag at zero lift of fully tapered swept wings of arbitrary section, *Coll. Aero. Cranfield Rep.* no. 76, 50 pp., Oct. 1953.

By the method of source distribution, the wave drag of a fully tapered swept wing of arbitrary section is expressed in terms of a double integral involving the variation of wing surface slope. In general, the wave drag may best be computed by numerical integration, which will be discussed in a later report.

In two particular cases, direct integration is possible for wing

with simple section shapes. One is the case of wing of infinite span and the other is the wing of high sweepback. The latter case is discussed in some detail in this report. S. I. Pai, USA

1898. **Küchemann, D., The distribution of lift over the surface of swept wings,** *Aero. Quart.* **4,** part 3, 261–278, Aug. 1953.

Paper is extension of author's previous investigation [Küchemann and Weber, AMR **4,** Rev. 3344] on the chordwise pressure distribution at the center section of a swept wing. A plausible simple interpolation function is now suggested for approximating the chordwise pressure distribution, as well as the (effective) sectional lift slope, at other spanwise stations. For a finite swept wing, the induced downwash due to trailing vortexes is further assumed to be unaffected by the sweepback. On this basis, the spanwise load distribution for a finite swept wing is formulated into an integral equation of identical type as the Prandtl lifting line. Applications to the so-called "first," "second," and "third" problems of wing theory are discussed. Several simple calculations of the spanwise lift distribution and center-of-pressure locations show excellent agreement with experiment.

Reviewer feels that certain aspects of the theory are essentially semirational. But, due to the relative simplicity, it certainly warrants consideration in practical applications. The question of its range of validity can only be settled through experience.

S. F. Shen, USA

1899. **Mirels, H., Gap effect on slender wing-body interference,** *J. aero. Sci.* **20,** 8, 574–575, Aug. 1953.

Slender-body theory is used to calculate the loss of lift due to a gap between the root of a wing and a cylindrical body, both at the same angle of attack. The loss of lift for even the most minute gap is relatively large. It is noted that viscous effects would modify the results for small gaps. G. E. Nitzberg, USA

1900. **Garner, H. C., Note on aerodynamic camber,** *Aero. Res. Counc. Lond. Rep. Mem.* 2820, 14 pp., Apr. 1950, published 1953.

This note explains the theoretical significance of camber derivatives and also assesses the various available methods of making experimental measurements with particular reference to the use of a curved-flow tunnel. Systematic information is needed about the influence of curvature of flow on control hinge moments as a step toward the understanding of three-dimensional viscous flow.

Aerodynamic camber and the present state of knowledge of its aerodynamic derivatives are described. Camber derivatives are required for evaluating tunnel interference corrections and are useful for estimating corrections for aspect ratio and scale effect, in so far as the flow at a section of a finite wing can be represented as an equivalent two-dimensional flow. This quasi two-dimensional approach to the problem of control surfaces should be combined with experimental checks on the aerodynamic derivatives of various wings with flaps and also with a study of three-dimensional boundary layers.

Formulas for the camber derivatives of lift and pitching moment need confirmation. The derivatives of lift at the stall and of hinge moments over the whole range of incidence are virtually unknown and, in consequence, the determination of $(C_L)_{\max}$ and C_H is seriously limited. The significance of these two-dimensional camber derivatives is illustrated by the quantitative uncertainties that may arise. It is suggested that these might be removed by establishing formulas for the unkown derivatives from a series of tests of uncambered airfoils with a range of flaps in the curved-flow tunnel at the Langley Aeronautical Laboratory, USA, by simulating a uniform rate of change of pitch. The uncertain characteristics of the curved flow would make necessary a check between results so obtained and those deduced from tests in a straight tunnel of airfoils with various amounts of parabolic camber. There appears to be no other satisfactory technique for measuring camber derivatives.

From author's summary

1901. **Muggia, A., Aerodynamic characteristics of a flat plate airfoil fitted with flap and tab** (in Italian), *Atti Accad. Sci. Torino* **87,** 312, 12 pp., 1952–1953.

Conformal transformation is found carrying exterior of the unit circle over into flow region surrounding zero thickness, doubly kinked, straight-line profile, representing mean line of flapped noncambered airfoil fitted with control tab. Two stages in degree of approximation are illustrated in numerical applications, but refinements of any order are possible at expense of laboriousness. Over-all values computed for lift, pitching moment, and hinge moments do not differ markedly from findings stemming from slender-airfoil theory [see Durand's "Aerodynamic theory," section 11, chap. II, div. E], even though no great attempt for accuracy is made in numerical example presented; but now a nearly precise description of velocity (or pressure) distribution throughout flow field is provided for this somewhat oversimplified idealization of a flap-and-tab airfoil combination.

R. H. Cramer, USA

1902. **Vetter, H. C., Effect of a turbojet engine on the dynamic stability of an aircraft,** *J. aero. Sci.* **20,** 11, 797–798, Nov. 1953.

The author describes two direct effects and one indirect the turbojet engine has on the dynamic stability of the aircraft. The first two are the thrust component in direction of lift which can be considered by a simple additive term, and the Coriolis damping due to the forced motion of the gas in the jet duct of the engine. The third is a coupling effect between lateral and longitudinal modes of motion caused by the gyroscopic action of the rotating parts of the engine. The relative magnitude of these effects is discussed, and it is shown that some terms will have to be considered with the use of modern jet engines.

P. F. Maeder, USA

1903. **Walker, W. G., Gust loads and operating airspeeds of one type of four-engine transport airplane on three routes from 1949 to 1953,** *NACA TN* 3051, 34 pp., Nov. 1953.

About 50,000 hours of V-G data are analyzed. The normal acceleration increments for each of the three operations equaled or exceeded the limit gust-load factor, on the average, twice in about 1.0×10^6 flight miles. A derived gust velocity of 50 fps (evaluated on the basis of *NACA TN* 2964; AMR **7,** Rev. 245) was exceeded twice in about 0.5×10^6 flight miles for each of the three operations. G. Isakson, USA

1904. **Walker, W. G., Summary of revised gust-velocity data obtained from V-G records taken on civil transport airplanes from 1933 to 1950,** *NACA TN* 3041, 16 pp., Nov. 1953.

Previous data are re-evaluated on the basis of a "derived" gust velocity associated with a one-minus-cosine gust profile and the use of a revised formula [*NACA TN* 2964; AMR **7,** Rev. 245] in which gust factor is based on airplane mass ratio instead of wing loading. Conclusions drawn from original data, based on a linear-gradient gust profile, remain essentially unchanged.

G. Isakson, USA

1905. Bergrun, N. R., and Nickel, P. A., A flight investigation of the effect of steady rolling on the natural frequencies of a body-tail combination, *NACA TN* 2985, 27 pp., Aug. 1953.

A body-tail combination equipped with recording instruments and certain preset controlling actions on the horizontal and vertical control surfaces was dropped in five free-fall tests.

The angular motions of a missile in flight around its position of equilibrium are described by a pitching and a yawing motion and a rolling motion around its axis in direction of greatest dimensional extent. The frequencies of pitching and yawing (sinusoidal motions) are determined by the moments of inertia, the dynamic pressure q_0, chord $\bar{c}$, and exposed area S of the corresponding reference wing, formally represented by the static stability derivatives $C_{m\alpha} = -[(2\pi f_\theta)^2 I_y]/q_0 S\bar{c}$ and $C_{n\beta} = [(2\pi f_\psi)^2 I_z]/q_0 S\bar{c}$, respectively. These derivatives are changed if the body exhibits a steady rolling action (constant angular motion). There may even occur divergent motions, as found by the tests. They result when the rolling frequency approaches one of the "natural," undisturbed frequencies f_θ or f_ψ.

The relevant equations of motions were established by Phillips [*NACA TN* 1627].

Present tests are shown to render results in good agreement with theory, especially when influence of damping on f_θ and f_ψ is included. Tests were performed at Mach numbers between 0.9 and 1.1. Effects on $C_{m\alpha}$ and $C_{n\beta}$ of Mach number, altitude, and rolling action are reviewed on basis of acquired experience. Reviewer believes that tests of this nature form an indispensable complement to theoretical predictions in that they serve to confirm limits of stable operation hitherto only theoretically established.

J. R. Schnittger, Sweden

1906. Söhne, W., Lateral stability of a towed airplane (in German), *Ing.-Arch.* **21**, 4, 245–265, 1953.

As a pilot of towed load-carrying sailplanes during the war, the author found empirically that there exist serious difficulties about the static and dynamic stability of such airplanes. Therefore he undertook this thorough investigation of the lateral stability of towed airplanes. According to the method of small disturbances, the basic equations of lateral stability of an airplane towed by a flexible rope are given and thus the characteristic equation (frequency equation) which governs the dynamic stability of the motion. While the frequency equation of the classic lateral stability is of the fourth degree, the corresponding equation of the towed airplane is of the sixth degree. Normally, of the six roots of this equation there are two real roots λ_1, λ_6 and two pairs of complex roots $\lambda_{2,3}$ and $\lambda_{4,5}$. The large negative root λ_1 and the oscillatory root $\lambda_{2,3}$ are nearly the same as for the single airplane. The real root λ_6 determines the static stability, whereas $\lambda_{4,5}$ is the new root corresponding to a lateral oscillation of the motion, which usually is unstable. Because of its complexity, a general discussion of the frequency equation is impossible, but a large number of examples have been worked out numerically. There is a very great influence of the position of the point where the rope is fixed on the towed airplane, with regard to the center of gravity. Shifting this "fixing point" in front of the c.g. in horizontal direction, and also shifting it upward in vertical direction increases instability. Other parameters influence this instability as follows: (1) With increasing length of the rope, frequency and rate of increase of the unstable motion grow. (2) Increasing lift coefficient has the same influence. (3) With increasing angle of flight path, only the frequency of the unstable motion increases.

The author concludes that there is a satisfactory agreement of the theoretical results with the experience obtained in flight.

H. Schlichting, Germany

1907. Payne, P. R., A method of estimating helicopter performance, *Aircr. Engng.* **25**, 297, 344–358, Nov. 1953.

Paper presents a method for estimating helicopter performance at the project stage. Reviewer believes that there is nothing in the paper that is basically new and that author's claim that the method was found to give better agreement with flight and test tower results, as well as being quicker and more accurate than any so far developed, is hardly justified.

A. Gessow, USA

1908. Amer, K. B., Method for studying helicopter longitudinal maneuver stability, *NACA TN* **3022**, 52 pp. Oct. 1953.

In 1949, NACA established a practical criterion for desirable longitudinal maneuver stability of helicopters. It requires that, in level flight at $V_{\max}$, normal acceleration produced by 1-in. rearward stick displacement should pass through a maximum within two seconds following control motion. Present paper makes theoretical analysis of maneuver stability and results are compared with flight test measurements for both single- and tandem-rotor helicopters. Techniques are also described for determining significant stability derivatives in flight. Reviewer recommends this paper to all interested in assuring good flying characteristics of helicopters still in design stage, as well as to those wanting to improve flying characteristics of existing machines.

W. Z. Stepniewski, USA

1909. Stewart, W., and Sissingh, G. J., Dynamic longitudinal stability measurements on a single-rotor helicopter (Hoverfly Mk. I), *Aero. Res. Counc. Lond. Rep. Mem.* 2505, 24 pp., Feb. 1948, published 1953.

The results of stability flight tests on a single-rotor helicopter are presented together with a method of theoretical estimation of the stability of a helicopter. For the power-on flight condition, there is considerable variation in dynamic stick-fixed stability with forward speed. For the power-off flight condition (autorotation), there is little effect of speed on dynamic stability for the helicopter tested. The theoretical analysis does not show the variation in stability with speed evidenced by flight tests. Authors explain this difference as being due to the large variation in fuselage pitching moments with speed as effected by the induced flow from the rotor.

R. A. Young, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 1932)

1910. Hassig, H. J., Aerodynamic flutter coefficients for an airfoil with leading- and trailing-edge flaps in two-dimensional flow, *J. aero. Sci.* **21**, 2, 131–132, Feb. 1954.

In this brief note author proposes to use previously tabulated plain wing aerodynamic coefficients for the stated problem by shifts in reference points and superposition of displacements and loads. Procedure will involve extensions of tabulated coefficients to small values of reduced frequency. Reviewer remarks that at low values of reduced frequency, for low supersonic speeds, applicability of linearized unsteady-flow theory is doubtful and caution must be exercised.

H. N. Abramson, USA

1911. Zartarian, G., and Voss, H. M., On the evaluation of the function $f_\lambda(M,\omega)$, *J. aero. Sci.* **20**, 11, 781–782, Nov. 1953.

The Schwarz integral (arising in supersonic flutter analysis)

$$f_\lambda(M, \bar{\omega}) = {}_0\int^1 \exp(-i\bar{\omega}u)J_0)((\bar{\omega}/M)u)u^\lambda du$$

is developed in a power series in ω^n, the coefficients of which are

proportional to the product of $(\lambda + n + 1)^{-1}$ and certain finite series in M^{-1}; the latter are tabulated to nine significant figures for $n = 0 - 13$ and $M = 5/4, 10/7, 3/2, 5/3, 2, 5/2$.

J. W. Miles, USA

1912. **Beatrix, C., On the balancing of control surfaces** (in French), *Rech. aéro.* no. 34, 33–38, July-Aug. 1953.

Rapid qualitative method of mass-balancing control surfaces is obtained by grossly simplifying the problem. Paper presupposes knowledge of inertial parameters and shows importance of obtaining them. W. A. Mersman, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1696, 1705, 1717, 1933, 1962, 1963, 1992)

1913. **Ricardo, Sir Harry R., The high-speed internal-combustion engine, 4th ed.,** London and Glasgow, Blackie & Son, Ltd., 1953, ix + 420 pp. 40 s.

This fourth edition reviews the author's experience in the design, test, and development of the internal-combustion engine. Both the spark-ignition and compression-ignition types are treated in parallel.

The first five chapters cover, in general, fuels, combustion, and heat distribution between useful output and losses. The next 13 chapters treat the design and development of various engines in the author's laboratory, both for road vehicle and aircraft. Of interest to the American reader will be the discussion of the design and performance of the sleeve valve, in both the two-stroke-cycle and four-stroke-cycle engines. The final chapter, "Engines for research," is based on a half century of intensive research by the author, and covers problems peculiar to research leading to the development of engines for specific needs. This chapter covers the development of the various variable compression engines from the well-known E-35 to the present C.F.R. engines.

The reader familiar with the previous editions will find this edition an interesting supplement rather than a revision. Former editions treat fuels in more detail and mechanical design with some mathematical analysis. The fourth edition avoids the mathematical approach and should therefore be of great interest and value to those engaged in test and development.

C. J. Vogt, USA

1914. **Reynolds, R. L., Controlled starting of steam turbines,** *Trans. ASME* **75**, 8, 1461–1464, Nov. 1953.

Starting time of steam turbines is limited largely by need to maintain metal temperatures within 50 F to 100 F of steam temperature. If shutdown is to be short and high-temperature steam is available, turbine should be shut down quickly to retain maximum sensible heat. If only relatively low-temperature steam is available for starting, shutdown cycle should be adjusted to provide maximum cooling of turbine. Stresses in casings, horizontal flanges, and bolts caused by differential heating are listed as an important factor to control. A nomogram is provided showing the recommended time for bringing unit to speed following shutdown without dismantling. W. T. Reid, USA

1915. **Elston, C. W., Factors involved in starting and subsequent loading of modern steam turbines,** *Trans. ASME* **75**, 8, 1465–1468, Nov. 1953.

Frequent shutdowns of turbines, even nightly in some stations, cause problems in starting and loading because of lack of information on the magnitude of repeated thermal stresses and whether they will be harmful to turbine parts. Thermal stresses in casings and rotors, differential expansion between rotor and stationary parts, and temperature differentials between flanges and flange bolts must be controlled. Rapid starting is not necessarily undesirable if rate of change of temperature of turbine parts is relatively low. W. T. Reid, USA

1916. **Wilson, C. D., Quick-starting of steam turbines,** *Trans. ASME* **75**, 8, 1473–1475, Nov. 1953.

Shows typical nomogram for simplifying loading program for turbine. W. T. Reid, USA

1917. **Persh, J., and Bailey, B. M., Effect of surface roughness over the downstream region of a 23° conical diffuser,** *NACA TN* 3066, 57 pp., Jan. 1954.

Since previous investigations had shown that roughening of surface could stabilize flow in duct diffusers having less length and greater angle than are required for best performance, tests were made to determine whether efficiency of such diffusers could be improved by proper distribution of roughness. Best efficiency was obtained with diffuser almost completely roughened (97%), loss of total pressure then being considerably less than for smooth surface. Flow was steady and reproducible at all conditions. C. W. Smith, USA

1918. **Scholz, N., Two-dimensional correction of the outlet angle in cascade flow,** *J. aero. Sci.* **20**, 11, 786–787, Nov. 1953.

This paper presents an approximate method for estimating the two-dimensional correction of the outlet angle for cascade flow, due to boundary-layer growth on the side walls of the cascade tunnel. Author replaces the cascade airfoils with a series of single vortexes acting at the location of the aerodynamic centers. He then divides the flow through the channel into two regions: one upstream of the plane through the equivalent vortexes, and the other downstream, with the simplifying assumption that the entire flow deflection takes place downstream of the vortex row. Application of momentum considerations gives the correction to the outlet angle in terms of a ratio of flow contractions in the two regions on either side of the vortex row. This ratio can be expressed in terms of an experimentally determined constant, which proved to have approximately the same value for the range of tests carried out in the author's tunnel. Adopting a fixed value for this constant gives a simple solution to the correction of the outlet angle. F. L. Wattendorf, USA

1919. **Kemp, N. H., and Sears, W. R., Aerodynamic interference between moving blade rows,** *J. aero. Sci.* **20**, 9, 585–597, 612, Sept. 1953.

Turbomachine blades move through a nonuniform field of flow, disturbed by the induced effects of other stationary and moving blade rows. Study deals with basic case of a single stator followed by a single rotor. Fluid is assumed incompressible, and circular blade arrangement is replaced by an infinite double cascade of two-dimensional airfoils. Viscosity is, of course, neglected and the von Kármán-Sears unsteady airfoil theory being used, study is limited to cascades of thin, slightly cambered blades; thus it is more applicable to compressor stages than to turbines. Due to obvious mathematical difficulties, only an approximate calculation is presented, based upon an iteration procedure. Numerical computations show fluctuating lift values of magnitudes as great as 18% of steady lift. Effects of stator wakes on unsteady lift of rotor blades are comparable to induced effects of stator blades themselves.

Paper is a valuable attempt to study a very complex aspect of fluid flow in axial turbomachines. P. Schwaar, France

1920. Jeffs, R. A., Hartley, E. L., and Rooker, P., Tests on an axial compressor with various stator blade staggers, *Aero. Res. Counc. Lond. curr. Pap.* 132, 18 pp., Sept. 1950, published 1953.

Paper presents the results of a series of low-speed tests on 6 stages of a medium stagger-free vortex design of axial compressor blading, in which the stagger of the stator blades was varied over a wide range while the rotor-blade stagger remained at its design figure. It is shown that efficiencies in excess of 85% were achieved over a range of stator-blade stagger from $-50°$ to $+10°$, compared with the design figure of $-25.4°$. This performance augurs well for the improvement of the performance of axial-flow compressors away from their design point by the method of altering the stator-blade stagger in some of the stages.

From authors' summary

1921. Johnston, I. H., An analysis of the air flow through the nozzle blades of a single stage turbine, *Aero. Res. Counc. Lond. curr. Pap.* 131, 18 pp., Feb. 1951, published 1953.

Presents the results of detailed traverses made on three of the nozzle assemblies designed for a single-stage experimental turbine. The effects of *pitch/chord* ratio on gas outlet angle and total head loss are recorded and discussed in the light of corresponding work published elsewhere. The value of *pitch/chord* ratio giving minimum total head loss is found to compare well with the optimum pitching given by two-dimensional results obtained from cascade tests on blades of a similar nature.

From author's summary

1922. Traupel, W., Vortex systems in airfoil cascades and in turbines (in German), *ZAMP* **4**, 4, 298–311, 1953.

The physical development of the primary and secondary vortex systems associated with cascade blades placed between parallel walls is discussed. Approximate formulas are presented for the strength of these vortexes. Further sections deal with twisted blades having constant circulation, the energy lost, and applications to turbomachinery. Some unsteady periodic disturbances in rotating blade passages are stated to be due to this phenomenon.

The reviewer notes that, following Eq. (1), the equation of continuity is wrongly presented and, hence, Eq. (2) is incorrect. This error does not affect the main arguments in the paper.

G. M. Lilley, England

Flow and Flight Test Techniques

(See also Revs. 1870, 1874, 1881, 1938)

1923. Bean, H. S., Johnson, R. M., and Blakeslee, T. S., Small nozzles and low values of diameter ratio, ASME Ann. Meet., New York, Dec. 1953. Pap. no. 53—A-155, 17 pp.

Duplicate sets of previously calibrated (with air) nozzles as specified by Heat Exchange Institute (HEI) for small sizes (10 nozzles with throat diameters $^1/_{16}$ to 1 in.) were calibrated by weighed-water measurements. Adapters were developed for installation in 1-, 2-, and 4-in. pipes with HEI and ASME (radius) tap locations. For most nozzles, agreement between original air and present water calibrations is well within range of experimental uncertainties. Results emphasize the necessity of calibration of nozzle and pipe assembly as a unit when accuracies of better than 1% are required. Otherwise, in range throat Reynolds number from 50,000 to 200,000, average coefficient from ASME Fluid Meters Committee curves are satisfactory. Need for further work with 1-in. nozzle in 4-in. pipe is indicated.

R. G. Folsom, USA

1924. Li, Y. T., High-frequency pressure indicators for aerodynamic problems, *NACA TN* 3042, 52 pp., Nov. 1953.

The general requirements for pressure transducers, particularly for use in aerodynamics research, are outlined. The fundamental relationships of natural frequency, area, mass, spring constant, and sensitivity of the instrument are shown. Author describes and compares the performance of five basic types of mechanical construction for converting pressure to mechanical motion in an electrical mechanical pressure transducer. Three complete transducers with natural frequencies varying from 15,000 to 60,000 cps are described and their performance tabulated.

A method for the dynamic calibration of high-frequency pressure transducers using a shock tube is described. A step function, generated at the end of the shock tube, is applied to the instrument under test and its dynamic response is recorded. Frequency-response curves for the instrument may be obtained from its step function response by harmonic analysis or from curves presented in the paper.

E. R. Spaulding, USA

1925. Bachmann, W., Setups for pressure gage testing (in German), *Feinwerktech.* **57**, 10, 306–308, Oct. 1953.

The accurate calibration of manometers and pressure gages by means of master standards requires that influence of connecting lines, kind of test liquid, effect of air bubbles in the lines, etc., be taken into account. Some of the main sources of calibration errors and means for their correction are explained and illustrated by layout drawings of typical test setups.

H. J. Ramm, USA

1926. Sibert, H. W., Relation of force, acceleration, and momentum for a body whose mass is varying, *J. aero. Sci.* 20, 2, 141–142, Feb. 1953.

Note in Readers' Forum.

1927. Pope, A., Note on model effective span for wind-tunnel wall corrections, *J. aero. Sci.* **20**, 11, 793–794, Nov. 1953.

Discussion concerns proper effective span for computation of wall interference on wings in subsonic wind tunnels. Author assumes that the average of the vortex span and the true wing span is the correct effective span for this computation. Comparison with the more elaborate computations of *NACA TR* 770 yields good support for this assumption.

H. J. Allen, USA

1928. Eggink, H., The improvement in pressure recovery in supersonic wind tunnels, *Aero. Res. Counc. Lond. Rep. Mem.* 2703, 18 pp., May 1949, published 1953.

The inefficient pressure recovery of present-day supersonic wind tunnels, which leads to high costs of plant installation and operation, is discussed and methods of improvement suggested. In particular, the diffuser system, where most of the losses occur, is studied in detail; the improvement to be expected in the pressure recovery by the use of convergent-divergent types is explained and methods of overcoming the necessity for high starting powers with this arrangement are presented.

Diffuser experiments based on recent investigations into breakaway phenomena in supersonic flow are described, which result in a considerable improvement of pressure recovery. A deceleration from $M = 2.48$ at the working section to $M = 1.42$ at the diffuser throat was obtained, using a variable diffuser throat.

From author's summary

1929. Bottle, D. W., and Somerville, T. V., Tests on the Hurricane L. 1696 in the 24-ft wind tunnel, *Aero. Res. Counc. Lond. Rep. Mem.* 2562, 10 pp., Aug. 1941, published 1953.

1930. **Young, A. D., and Marshall, W. S. D., No. 2, 11½-ft wind-tunnel tests of a small span, small chord double aileron for use as a lateral control on a high-lift aircraft,** *Aero. Res. Counc. Lond. Rep. Mem.* 2536, 32 pp., Feb. 1946, published 1952.

Tests were made on a 1/2.25 scale model of a half wing of the Master. The span of the aileron was $0.22s$ and the chords were $0.2\bar{c}$ and $0.15\bar{c}$; the aileron was fitted with a balance tab of $0.05\bar{c}$ chord. Measurements were made of the hinge moments, lift increments (from which the rolling moments were deduced), and the pressures in the aileron gaps just above and below the seals. The latter were required for estimating the effect of internal shrouded nose (or pressure) balances. Tests were also made of the effect on the hinge and rolling moments of a small spoiler situated just aft of the front aileron vent; the spoiler was assumed to emerge on the lower surface of the down-going aileron and on the upper surface of the up-going aileron.

From authors' summary

1931. **Tucker, M. J., Sea-wave recording,** *Dock Harb. Author.* 34, 397, 207–210, Nov. 1953.

Instruments used for measuring and recording ocean waves are described briefly and informatively. Methods mentioned are those used by the National Institute of Oceanography, England. Included are airborne and ship-borne recorders. Field experience is discussed.

R. S. Arthur, USA

1932. **Scanlan, R. H., A steady-flow aeroelastic study by electrical analogy,** *J. aero. Sci.* 20, 10, 691–698, Oct. 1953.

Author describes use of the electrical tank "lifting-surface calculator" of Malavard and Duquenne for an aeroelastic study. New items are (1) applicability of this electrical analogy to the calculation of certain "elementary" aerodynamic effects in compressible flow, and (2) specialization of structural influence coefficient concepts, permitted by availability of new means of aerodynamic calculation by avoiding oversimplified notions, such as that of an elastic axis and of the rigidity of lifting surface in wind or flight direction. Suggestions are made for subsonic compressible-flow aeroelastic lift-distribution studies and for accounting for large dihedral effects on incompressible-flow distributions.

From author's summary by R. G. Folsom, USA

1933. **Herzig, H. Z., Visualization studies of secondary flows with applications to turbomachines,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-56, 18 pp.

Super- and subsonic investigations of the secondary flow in two-dimensional and annular cascades are described. By visualization methods (smoke, paint, hydrogen-sulphide traces on lead-carbonate paint), a passage vortex in the shroud region due to the pressure gradient could be traced. Moreover, radial flows on suction side and trailing edge were found in annular cascades. The energy losses were determined by total pressure measurements. To get an insight into the flow in the blade-end regions, the effect of tip clearance was investigated. By an endless belt a relative motion between the blades and one end wall was provided. These investigations can represent the flow conditions in turbine nozzles and straighteners. In the case of rotating cascades, the relevant centrifugal influence will change the flow picture comprehensively.

H. Krüger, Germany

1934. **Giese, J. H., and Bergdolt, V. E., Interferometric studies of supersonic flows about truncated cones,** *J. appl. Phys.* 24, 11, 1389–1396, Nov. 1953.

Paper presents experimental data on mixed sub- and supersonic gas flow about nose of a truncated cone cylinder in axial flight at Mach 2.45. By direct comparison of fringe shifts in interferograms of 0.30-in. diam projectiles, the flow about truncated cones is compared with the flow about cones, and the region of convergence of the former to the latter was determined in a qualitative way. By varying the size of the truncation and density of atmosphere, the comparison of fringe shifts was also used to show that flow fields with the same Reynolds number are similar. Density distributions determined by actual evaluation of several interferograms are compared with theoretical nonviscous flow to provide an estimate of the accuracy of the interferometric measurements and to illustrate the nature of deviations of the flow theory from actual flow. The "null method" of comparison of interferograms to avoid tedious quantitative evaluation of interferograms is a useful technique, and the results obtained in this case should be helpful in designing future experiments and analysis aimed at quantitative evaluation of flow fields about blunt bodies in supersonic flight.

E. W. Price, USA

Thermodynamics

(See also Revs. 1913, 1948, 1958, 1962, 1970, 2022, 2039)

1935. **Whalley, E., and Schneider, W. G., Compressibility of gases—VIII; Krypton in the temperature range 0–600 C and pressure range 10–80 atm,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-85, 10 pp.

Second and third virial coefficients are reported for Krypton gas. Paper is one of a series from National Research Council of Canada giving experimental data on the compressibility of He, A, CF_4, SF_6, CO_2, and Kr, with special reference to determining the form of intermolecular force fields. Earlier measurements on Krypton elsewhere deviate slightly from the values reported here [*J. chem. Phys.* 20, 1615–1618, 1952].

W. Griffith, USA

1936. **Riddell, R. J., Jr., and Uhlenbeck, G. E., On the theory of the virial development of the equation of state of monoatomic gases,** *J. chem. Phys.* 21, 11, 2056–2064, Nov. 1953.

Paper deals with the asymtotic behavior of the virial coefficients of high orders in the equation of state. Main body of treatment is purely mathematical, using statistical technique in the theory of graphs to determine the various possible types of intermolecular forces among large number of molecules. The actual problem in evaluating certain integrals giving the contributions of intermolecular forces to the partition function is merely touched upon. Some results for special cases are given.

L. S. Dzung, Switzerland

1937. **Bird, R. B., Hirschfelder, J. O., and Curtiss, C. F., The theoretical calculation of the equation of state and transport properties of gases and liquids,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-87, 28 pp.

An excellent summary of the present state of the field. A short discussion of intermolecular forces is given. Important results from equilibrium statistical mechanics and kinetic theory are presented, along with means of calculating the coefficients of diffusion, viscosity, and thermal conductivity of dilute gases, dense gases, and liquids. Functions are given in tabulated form permitting engineering calculations to be made. For those cases where theory is not yet in usable form, the "principle of corresponding states" is discussed. A good bibliography is given.

Reviewer recommends this paper to those interested in the current state of the theory and the computation of transport properties of gases and liquids for engineering use.

R. A. Gross, USA

1938. Kestin, J., and Pilarĉzyk, K., Measurement of the viscosity of five gases at elevated pressures by the oscillating-disk method, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-67, 11 pp.

Paper describes the measurement of the influence of pressure on the viscosity of five commercially pure gases: Air, nitrogen, hydrogen, argon, and helium, in a range up to about 70 atm (1000 psi) at room temperature (20 or 21 C). The viscosity was measured by observing the period of oscillation and the logarithmic decrement of an optically ground-quartz disk of 70-mm diam suspended on a thin rhodium-platinum wire between two fixed optically ground-quartz plates with a separation of 1 mm and performing torsional oscillations. The data were evaluated on the basis of Macwood's equations, but the instrument proved capable of a higher accuracy of measurement than the 1% inherent in the theory. The scatter of experimental data did not exceed 0.1% and repeatability was of the same order of accuracy. In view of the mathematical difficulties, no attempt is made to improve the theory of the instrument but it is shown that the motion of the disk is nonlinear and that the relation between the period of oscillation and the logarithmic decrement is not that which would be expected on the assumption of simple damped harmonic motion.

From authors' summary by Ruth N. Weltmann, USA

1939. Doolittle, A. K., Comment on the temperature dependence of the viscosity of liquids, *J. appl. Phys.* **24,** 8, p. 1067, Aug. 1953.

1940. Gutmann, F., and Simmons, L. M., Further note on the temperature dependence of the viscosity of liquids, *J. appl. Phys.* **24,** 8, 1067–1068, Aug. 1953.

1941. Barrow, G. M., Vapor heat capacities determined by the use of vapor pressure equations, *J. chem. Phys.* **21,** 11, 1912–1913, Nov. 1953.

Arguments are presented to justify the following vapor-pressure p equation for liquid-vapor equilibria involving nonideal gases

$$\log p = A - [\Delta H_0/2.303(RT)] + (\Delta C_p/R)\log T + [ap/2.303\,(RT)^2]$$

Here A is a constant; ΔH_0 = molar heat of evaporation at 0° K; ΔC_p = difference in molar liquid and vapor heat capacities at constant pressure; a = van der Waals' constant; R = molar gas constant; T = temperature. The vapor-pressure equation provides quantitative correlation of experimental data for a variety of different liquids, including long-chain hydrocarbons, water, and liquid mercury. It may be used to calculate the vapor heat capacity from vapor pressure data if the heat capacity of the liquid is known.

S. S. Penner, USA

1942. Bullen, T. G., A simple method of determining the latent heat of steam, *Amer. J. Phys.* **21,** 8, 645–647, Nov. 1953.

An apparatus has been described for determination of heat of vaporization utilizing the equation between electrical power input and mass rate of condensation of an evaporating fluid. Measurement is made of the rate at which electrical energy is supplied to produce steady-state evaporation in an enclosed inverted flask. A condenser tube is inserted to collect the condensate for weighing. At constant evaporation temperature, thermal losses should not vary with evaporation rate and may be eliminated in simultaneous solution of repeated runs.

H. M. Spivack, USA

1943. Butuzov, V. P., Gonikberg, M. G., and Smirnov, S. P., Measurements of melting points of metals under extremely high pressures, Nat. Sci. Found. tr-76, Sept. 1953; *Doklādi Akad. Nauk SSSR (N.S.)* **89,** 4, 651–653, Apr. 1953.

Paper describes experimental apparatus and procedure used in the determination of melting points of metals at very high pressures. Data for bismuth at pressures up to 22,200 kg/cm² are given.

A. B. Cambel, USA

1944. Hardy, J. K., Kinetic temperature of wet surfaces, *Aero. Res. Counc. Lond. Rep. Mem.* 2830, 13 pp., Sept. 1945, published 1953.

1945. Zoss, L. M., Suciu, S. N., and Sibbitt, W. L., The solubility of oxygen in water, *Trans. ASME* **76,** 1, sect. 1, 69–71, Jan. 1954.

Authors state: "The solubility of oxygen in water was measured at pressures of 1000, 1500, and 2000 psia and at temperatures from 32 to 625 F." Oxygen at high pressure was added to vapor space over water in an agitated autoclave. After attaining equilibrium, liquid sample was removed and quantity of gas that had been absorbed was determined by volume measurement of gas released on reducing pressure.

Observed values shown in paper cover only temperatures from 90 to 520 F. Reviewer has calculated Henry's law constant $K = P_A/S_A$, where K is const, dependent on temperature, P_A is partial pressure of oxygen, psia, and S_A is solubility of oxygen, cc (s.t.p.) O_2/gm H_2O, as follows: 710 at 100 F, 900 at 200 F, 720 at 300 F, 640 at 325 F, 450 at 400 F, 270 at 500 F. Authors point out that "Henry's law cannot be used to predict the solubility over a wide pressure range. Actually, the solubility would increase to a maximum value and then decrease with increasing partial pressure of oxygen." Since tests only covered two-to-one pressure range, reviewer considers these remarks applied to comparison between authors' results and those of others. No tests were made to show whether departure from Henry's law at low pressures is real or is result of discrepancies in test procedures. Maximum solubility was not reached in tests.

D. Aronson, USA

1946. Glansdorff, P., Contribution to the minimum entropy increase question (in French), *Physica* **19,** 8, 689–704, Aug. 1953.

A new extremal principle for the entropy production in irreversible processes during a finite time interval is derived; no restrictions such as small deviations from equilibrium are made. The phenomenological relations between fluxes and forces are not used. It is remarkable that variations of the density which violate the equation of continuity are necessary. A connection with Prigogine's extremal principle is stated, but, in reviewer's opinion, the conditions for the extremal problem differ essentially from those of Prigogine's principle.

J. Meixner, Germany

Heat and Mass Transfer

(See also Revs. 1743, 1830, 1858, 1879, 2040)

1947. Parker, H. M., Transient temperature distributions in simple conducting bodies steadily heated through a laminar boundary layer, *NACA TN* 3058, 42 pp., Dec. 1953.

Paper presents an analytical investigation of the effects of internal conduction on the aerodynamic heating of semi-infinite bodies represented by a flat plate, a conical shell, and a slender solid cone. Only the one-dimensional transient temperature distribution parallel to the infinite stream axis is considered, and the heat input during steady flight beginning at zero time in a homogeneous and constant-altitude atmosphere is assumed to be

only that transferred through an incompressible and laminar isothermal boundary layer. Evaluated solutions by an iteration method of successive-order approximations indicate that internal conduction has a substantial effect on the longitudinal temperature profile only over the most forward portion of the body (in this connection, see also AMR **4**, Rev. 2137), the extent of the conduction region increasing with the square root of time and linearly with Mach number. P. J. Schneider, USA

1948. **Hilsenrath, J., and Touloukian, Y. S., The viscosity, thermal conductivity, and Prandtl number for air, O_2, N_2, NO, H_2, CO, CO_2, H_2O, He, and A,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-186, 34 pp.

The low-pressure viscosity and heat-transfer parameters—thermal conductivity and Prandtl number—are tabulated for air, nitrogen, oxygen, hydrogen, argon, carbon monoxide, carbon dioxide, nitric oxide, steam, and helium. The values reported are based on recent critical correlations of the thermodynamic and transport properties of these gases at the National Bureau of Standards. The properties are tabulated for atmospheric pressure and extend from 100 K (180 R) to as high as 2000 K (3600 R) in some instances. The effect of pressure on the viscosity is presented in tabular form for oxygen, nitrogen, hydrogen, steam, carbon dioxide, and argon for pressures up to 100 atm in the experimental range of temperatures. The Prandtl numbers for air given in this work are compared with existing published and unpublished values which are in extensive use. Plots are included showing the scatter among the experimental data and deviations between them and the tabulated values. They present a very clear picture of the extent and concordance of the experimental data. A nomogram is included for obtaining fractional powers of the Prandtl number.

From authors' summary by G. A. Hawkins, USA

1949. **Wolkenstein, W. S., Rapid method for determination of thermal characteristics of poor heat conductors** (in German), *Technik* **8**, 9, 593–596, Sept. 1953.

A thin, parallel plane plate of the test material is mounted between a constant-temperature source and insulation of known thermal characteristics. Absolute measurement of the thermal diffusivity requires two minutes. The thermal conductivity is obtained by comparison to the properties of the insulation.

W. L. Sibbitt, USA

1950. **Van Itterbeek, A., Forrez, G., and Mariens, P., Measurements on thermal diffusion with the use of ultrasonics,** *Physica* **19**, 6, 525–534, June 1953.

Thermal diffusion is measured of H_2-N_2 mixtures. Concentrations are determined from measurements of sound velocity, using acoustical interferometer. Temperatures for measurements were 291 K and 90 K. The acoustical method is held to be more accurate than the measurement of viscosity formerly used for concentration determinations (precision sound velocity 0.5%, precision viscosity 1%). H. C. Brinkman, Indonesia

1951. **Lauwerier, H. A., Optimum problems in the conduction of heat in a semi-infinite solid,** *Appl. sci. Res.* (*A*) **4**, 2, 142–152, 1953.

Author considers a semi-infinite solid initially at zero temperature. Heat is transmitted to the solid by applying a constant temperature or a constant flux at the boundary. In this manner, the solid is heated for a given time interval and then the boundary is insulated. Through this method, it is desired to obtain a specified temperature at a given location inside the solid using minimum heat supply. Optimum conditions for effecting this are derived in terms of the applied temperature or the applied flux. Method used consists of applying extremalizing conditions to available classical heat-flow solutions. The criteria for a minimum energy process are formulated.

R. B. Grant, USA

1952. **Mitchell, A. R., Round-off errors in the solution of the heat conduction equation by relaxation methods,** *Appl. sci. Res.* (*A*) **4**, 2, 109–126, 1953.

Author formally discusses round-off errors in the numerical solution of the potential equation $\partial^2\varphi/\partial x^2 = \partial\varphi/\partial t + f(x, t)$, using a rectangular subdivision, the stable six-point formula for relaxation of the spatial coordinate x, and step-by-step method for the time coordinate t. The magnitude and nodal location of maximum round-off errors are investigated for several network sizes and assumed distribution of network residuals.

P. J. Schneider, USA

1953. **Bergelin, O. P., Brown, G. A., and Colburn, A. P., Heat transfer and fluid friction during flow across the banks of tubes—V,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-173, 17 pp.

The experimental results of a research program on tubular heat exchangers have been extended from unbaffled rectangular tube banks to a cylindrical baffled exchanger designed so that internal leakage can be eliminated or accurately controlled. Pressure drops across a single cross-flow section and a single window are measured during viscous and turbulent flow for heating, cooling, and isothermal conditions. The exchanger is 5.25-in. ID and contains eighty $^3/_8$-in.-diam tubes on a staggered square arrangement with a 1.25 pitch ratio. Baffle cut-downs of 18, 31, and 43% of the shell diameter and baffle spacings from 0.5 to 3.7 in. are covered. The ratio of cross-flow area to window area varies from 0.224 to 1.64. The Reynolds-number range is 2.5 to 14,000. The friction results for the cross-flow section agree well with previous data on simple cross-flow units in the turbulent region, but are somewhat lower in the viscous region. The pressure loss in the baffle window is found to be part friction and part kinetic loss in turbulent flow and practically all friction in viscous flow. The heat-transfer data are determined as average values of heat-transfer coefficients for the entire exchanger. A means is presented for estimating the heat-transfer rate in the baffle-window section which makes it possible to determine the results in the cross-flow section. The latter agree well with simple cross-flow data in the turbulent region, but, like the friction results, are somewhat low in the viscous region.

From authors' summary by C. C. Eckles, USA

1954. **Seban, R. A., Jr., Levy, S., Drake, R. M., and Doughty, D. L., The effect of single roughness elements on the heat transfer from a 1:3 elliptical cylinder,** *ASME Trans.* **76**, 4, 519–526, May 1954.

A single spanwise surface roughness element has been placed in the laminar boundary layer of the cylinder and its effect on local heat-transfer coefficient, recovery factor, and pressure coefficient has been investigated in the range of Reynolds number $5 \cdot 10^5$ to $1.2 \cdot 10^6$ (based on chord) and local Mach number 0 to 0.6. With a sufficiently big roughness element, transition to turbulent flow occurs and, after the transition point, the heat-transfer coefficient was in good agreement with values given by the Colburn equation. If roughness element is 10 times the momentum thickness of boundary layer, extended regions of flow separation seem to appear with heat-transfer coefficients larger than those given by the Colburn equation.

H. Schuh, Sweden

1955. Beckwith, I. E., Heat transfer and skin friction by an integral method in the compressible laminar boundary layer with a streamwise pressure gradient, *NACA TN* 3005, 55 pp., Sept. 1953.

The von Kármán-Pohlhausen integral solution to the momentum equation and a corresponding integral treatment of the energy equation are examined for the solution of boundary-layer problems including local friction and heat-transfer coefficients in cases in which streamwise pressure gradients may exist. Fourth-degree polynomials are used for velocity profiles, and 4th-, 5th-, or 6th-degree polynomials are used with assorted wall and boundary-layer-edge boundary condition for the thermal profiles.

Besides a discussion of the general procedure, application is made to the flow of a perfect gas with constant specific heat and Prandtl number, and comparison is made with exact solutions and experimental results for the flat plate, stagnation region, and cylinder. The comparisons show the higher-degree polynomials agree reasonably well with the exact solutions. Unfortunately, the same polynomials and the same location of boundary conditions do not serve equally well in all cases, and no clear rule is obtained which would permit the selection of the proper polynomial approximation appropriate to any given new case. In an appendix, the effect of lateral radius of curvature on skin friction and heat transfer in the laminar boundary layer is discussed.

The principal simplifying assumptions and procedures used in the report are: (1) Equal thermal and velocity boundary-layer thicknesses; (2) linear viscosity temperature relation; (3) use of the first coefficient in the polynomials for the stagnation temperature profile as one of the unknowns in the final solution of the momentum and energy equations; (4) application of the Holstein-Bohlen method to avoid the use of the second derivative of the stream velocity. H. W. Emmons, USA

1956. Gershuni, G. Z., On free convection in space between vertical coaxial cylinders (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **86**, 4, 697–698, Oct. 1952.

1957. Kuscer, I., Penetration of radiation through a thick slab of isotropically scattering material, *Canad. J. Phys.* **31**, 7, 1187–1188, Nov. 1953.

1958. West, W. E., Jr., and Westwater, J. W., Radiation conduction correction for temperature measurements in hot gases, *Indust. Engng. Chem.* **45**, 10, 2152–2156, Oct. 1953.

Authors derive an expression

$$(T_G - T_W)/(T_E - T_W) = (h_c + h_R)/h_c \times (\cosh nb)/(\cosh nb - 1)$$

for the accurate measurement of the temperature of a hot gas T_G when a temperature-sensitive probe inserted in the gas stream indicates a temperature T_E. The method is applicable to low velocity gas streams, where the wall temperature T_W, the convection h_c, and radiation h_r heat-transfer constants may be readily determined from the conditions of the experiments. In such cases the method gives results in good agreement with that of other known methods. J. E. Brock, USA

1959. Smith, J. W., Effect of gas radiation in the boundary layer on aerodynamic heat transfer, *J. aero. Sci.* **20**, 8, 579–580, Aug. 1953.

1960. Van Der Held, E. F. M., The contribution of radiation to the conduction of heat, *Appl. sci. Res.* (A) **4**, 2, 77–99, 1953.

Continuing the author's study of the contribution of radiation to the conduction of heat [AMR **5**, Rev. 2727], two solutions of "the complete equation of Fourier" are presented. First solution considers the steady state for boundary conditions without mutual influence of surfaces. Second solution considers steady state with boundary conditions for thin layers.

Solutions appear to be verified by test results. Mathematically, the paper is complicated and does not make for easy reading; however, it should prove valuable to those interested in this phase of heat conduction. W. A. Wolfe, Canada

1961. Dergarabedian, P., The rate of growth of vapor bubbles in superheated water, *J. appl. Mech.* **20**, 4, 537–545, Dec. 1953.

Although most practical cases of cavitation and boiling involve solid surfaces, the present theory of these phenomena quite properly begins by considering bulk liquid behavior. This paper first reviews, extends, and ties together the theories of M. S. Plesset [AMR **3**, Rev. 2697] and of Plesset and S. A. Zwick [AMR **5**, Rev. 1874] and a second paper in preparation. Then experimental data are obtained on bubble behavior in bulk superheated liquid. Bubbles were formed by infrared irradiation of water in an uninsulated pyrex beaker. Their growth was measured from multiflash photographs obtained at 1000 frames/sec. Data were obtained at five different temperatures from 101.4 to 105.3 C. The results are in close agreement with the Plesset-Zwick theory, which diverges markedly from the classic Rayleigh theory at times greater than a fraction of a millisecond. Deviation from the new theory is only noticeable after 10 millisec, where bubble motion begins to affect heat transfer.

Reviewer feels this is a valuable contribution and looks for additional work of this kind. Desirable extensions would be (a) to other liquids; (b) to shorter times ($\ll 10^{-3}$ sec) where the theory predicts some interesting effects; and (c) to longer times, correcting the theory to allow for bubble motion.

R. R. Hughes, USA

1962. Falkner, J. C., Quick-starting of large high-pressure high-temperature boilers, *Trans. ASME* **75**, 8, 1407–1460, Nov. 1953.

Rapid starting from cold of high-output boilers is becoming increasingly important as system growth provides opportunity for week-end shutdowns. Several benefits accrue from 1-hr starts in place of the more conventional 4- to 6-hr starts. Longer periods are provided for operation of more efficient equipment during low-load periods. Time available for week-end maintenance can be increased as much as 15%. Savings of 27 to 43% of the fuel required to put the boiler on the line is possible with quick starts. Review of experience with nine 1,000,000-lb per hr boilers shows that 1-hr starts cause no more trouble in general than 4-hr starts. Superheaters can be operated during the quick-starting period within safe temperature limits and without shortening element life. Drum-plate tangential stresses, in general, are not excessive with quick starts. Where drum-end stresses are too high, internal baffling or improved circulation may reduce it to allowable limits. Boiler expansion is more uniform during quick starts, mainly because firing rate can be held more constant.

W. T. Reid, USA

1963. Weismantle, A. R., Quick-starting of high-temperature high-pressure boilers, *Trans. ASME* **75**, 8, 1468–1472, Nov. 1953.

Rapid starting of high-temperature, high-pressure boilers depends largely on the design of the unit. Superheater elements in particular are susceptible to damage if gas temperatures exceed 1300 F at any time during the start. Water trapped in nondraina-

ble superheaters can be expected to cause trouble if high gas temperatures occur near the operating pressure. Although generalizations are undesirable, the best guide to safe operation is a good measurement of gas temperature entering the superheater.

W. T. Reid, USA

1964. **Fritzsche, A. F., The design and calculation of oil coolers** (in German), *ETH Prom.* no. 2057, 99 pp.; Zürich, Verlag Leeman, 1953.

This PhD. thesis is the result of a thorough investigation in oil-cooling problems made by one of the largest Swiss motor manufacturers.

The author does not try to express the results by means of a single power formula. A deep analysis into the physical and mechanical details of flow and heat-transfer mechanisms enables him to predict the performance characteristics of cross and parallel-flow coolers. Numerous tables showing the expected dimensionless heat conductivity number N_u^* ($= kd/\lambda$, d tube diameter, k specific conductance, and λ thermal conductivity) for several Reynolds numbers, laminar or turbulent flow, different pressure and viscosity relations, enable the designer to make a selection of the most suitable cooler for a particular problem. Subsequent chapters are devoted to a consideration of all factors involved in the performance characteristics, and, based on these, several nomograms for a preliminary calculation of cooler performance are given. The following chapter deals with a refined analysis of all the details overlooked in the preliminary part: Flow configuration in the cooler, influence of free area around the tubes, and more exact thermal conductivity and heat-transfer relationships.

In the last section an example is worked out, based on the work of B. E. Short. The calculated values are shown to be in far better agreement with the test results of Short's work than given by the formula of Short.

No doubt the author's approach does involve much more mathematical work, but the deeper understanding of the intricate heat-transfer mechanism as well as the practical results obtained thereby undoubtedly warrant the additional time spent.

A well-arranged table of symbols used would render this thesis useful to many research workers possessing only a limited knowledge of German.

M. Rand, Canada

1965. **Nock, O. S., Performance and efficiency tests on the "Britannia" locomotives,** *Engineer, Lond.* **196,** 5087, 5088; 103–104, 136–138, July 1953.

1966. **Deeg, E., Transient diffusion through laminated media** (in German), *Z. angew. Phys.* **5,** 10, 370–374, 1953.

In ceramics, the problem of diffusion of water from wet clay into the plaster form is of interest. The diffusivities of the two materials are different and so are their abilities to absorb water. Author sets up the diffusion equation appropriate to this problem and solves it for the transient case subject to two boundary conditions: The mass flux across the boundary is continuous; and, along a thin transition region in which the diffusivity changes linearly, a force q is acting on the diffusing particles in the direction toward the more absorbing medium. Eventually, the thickness of this transition layer is allowed to become zero. The force q is expressed in terms of what author calls the Nerst solubility coefficient, which is the ratio of the absorptivities of the two media.

Form of solution depends sensitively on the thickness of the media in either direction away from the boundary. This is illustrated by plots of solutions for particular numerical cases. It is also shown how the method can be extended to any number of plane layers.

W. Hitschfeld, Canada

1967. **Kryukov, S. N., and Zhukovitsky, A. A., A method for determining diffusion coefficients,** Nat. Sci. Found. tr-71, Sept. 1953; *Dokladi Akad. Nauk SSSR (N.S.)* **90,** 3, 379–382, May 1953.

Determination of coefficients for diffusion in solids can be simplified by using radioactive elements. Authors propose a method simpler than either (a) the method of removing layers, (b) the absorption method, or (c) the method of longitudinal sectioning. The proposed method is a modification of (b) so that the effects of absorption and reflection are nullified. Method is given as: "A layer of radioactive element is deposited on one side of a thin sample (30 to 100μ). Then, after diffusion annealing, the radioactivity of both sides of sample is determined as function of annealing time. The diffusion coefficient D is obtained from

$$\ln[(I_1 - I_2)/(I_1 + I_2)] = \ln K - \pi^2 Dt/l^2$$

where I_1 is counting rate on one side, I_2 rate on other side; K is a constant independent of time and of diffusion coefficient, l is the thickness of the sample, and t is time of annealing.

In order to reduce uncertainty in measuring activity arising from the geometrical factor, the same should be removed a distance of 5 to 10 mm from the counter tube.

The method was tested with silver and found satisfactory.

D. Aronson, USA

Combustion

(See also Rev. 1878)

1968. **Holland, B. H., The structure and stability of flat burner flames,** *J. Inst. Fuel* **26,** 155, 282–288, 2 plates, Dec. 1953.

Stability of burning of undiluted fuel gases issuing into still air is studied. Phenomena of lift, lifted flame, and blowoff are considered. This type of burning is employed in heating bath, ovens, etc., where uniform radiant heat is required.

Spark shadow photography of unlit and burning streams is used to correlate stability with flow mechanisms. Description of burning with cylindrical jets is given but no quantitative data. Major part of paper discusses flames from three types of commercial injectors having a flat fan-type pattern.

These commercial injectors were operated with a variety of fuels: Ethylene, town gas, hydrogen, carbon monoxide, and butane gas. Operation varied considerably with fuel changes. Anchored flames seated on the downstream end of the injector were found necessary for stable burning. Flat ends on injectors provided more stability than tapered ends. Impinging jets gave the most stable flame and the anchor flames were strongest.

Reviewer believes that dimensions of commercial injectors should have been included, at least enough to permit estimating jet velocities. Also, in remarking how little attention has been paid to diffusion-type flames, author seems to be unaware of some very informative papers on pages 254–300 of "Third symposium on combustion and flame and explosion phenomena" [Williams and Wilkins Co., Baltimore, Md., 1949].

E. E. Frost, USA

1969. **Spalding, D. B., Conditions for the stable burning of carbon in an air stream,** *J. Inst. Fuel* **26,** 155, 289–294, Dec. 1953.

Author demonstrates existence and nature of various equilibria by consideration of mass-transfer and chemical reaction rates. Case of combustion to CO is examined in detail, showing that a burning carbon surface may be extinguished either by increasing or decreasing the rate of air flow. If nonconvective heat losses are too high, it may be impossible for burning to persist at any air-flow rate. Method is indicated for general case of simultaneous formation of CO and CO_2. Lack of reliable data about

reaction constants precludes accurate calculation for this case. Calculations based on CO formation alone tend to underestimate range of stable burning. J. K. Kilham, England

1970. Wilson, E. M., The stability of ethylene oxide, *J. Amer. Rocket Soc.*, **23**, 6, 368–369, Nov.-Dec. 1953.

The stability of ethylene oxide under adverse pressurization conditions has been demonstrated by a series of tests in which the compound was pressurized at rates as great as 20,000 psi/sec and was ejected through small, sharp-edged orifices at high pressure drops. No detonations occurred in these tests, or even when the material was suddenly pressurized with oxygen and ejected against a stainless-steel block maintained at 1000 F.

From author's summary

1971. Kurz, P. F., Flame-stability studies with mixed fuels, *Indust. Engng. Chem.* **45**, 9, 2072–2078, Sept. 1953.

Mixtures of propane and hydrogen, of propane and propylene, of propane and ethane were mixed with excess air and burned at atmospheric pressure. Flow of all gaseous components was controlled and measured. Flame blowout in burner was used as a measure of flame stability. In no case was it found that presence of either fuel component either accelerated or inhibited the combustion process of the mixture.

By the same method hydrogen sulfide was shown to inhibit stability of hydrogen-sulfide propane mixtures, but to have no effect on hydrogen-sulfide hydrogen mixtures. Transition from laminar to turbulent flow in burner was detected and shown to have no effect on conclusions. R. Cornog, USA

1972. Crocco, L., and Cheng, S.-I., High-frequency combustion instability in rocket motor with concentrated combustion, *J. Amer. Rocket Soc.* **23**, 5, 301–313, 322, Sept.-Oct. 1953.

Unidimensional analysis of combustion instability assumed to be induced by inherent nature of the pressure dependence of combustion process time lag. This differs from other analyses of low-frequency instability by assumption that fuel and oxidizer injection system is insensitive to combustion chamber-pressure variations. Only longitudinal oscillations are considered. Concentrated combustion fronts are in selected axial locations in the idealized rocket motor.

Analytical results presented account for axial variations in position of combustion and for nozzle configuration. Predicted combustion-induced oscillation frequencies are slightly less than natural frequencies of system. Short nozzle is stated to be less stable than long nozzle of similar configuration. Quantitative evaluation of results by comparison to field cases was not attempted.

This paper is a companion paper to one of the same title in "Fourth Symposium on Combustion," page 865, Williams and Wilkins Co., Baltimore, Md., 1953. E. S. Starkman, USA

1973. Clark, T. P., Formation and combustion of smoke in Bunsen flames, *Indust. Engng. Chem.* **45**, 12, 2785–2789, Dec. 1953.

Author presents data and discussion of the burning capacity of externally supplied smoke by ethylene-air Bunsen flames, and of the effects of initial gas temperature, fuel-flow rate, and secondary air supply on smoke formation in benzene-air Bunsen flames. Experiments were performed on a laboratory bench scale apparatus, utilizing glass equipment where feasible. The ethylene-air flame was found to burn relatively large amounts of carbon smoke provided the smoke was finely divided and sufficient oxygen was present to react with all the carbon while it was in the hot outer cone. The smoking point fuel-air ratio for the benzene-air flame was found to be independent of initial fuel temperature, to decrease with increasing fuel-flow rate, and to increase toward an asymptotic value with increasing secondary air-flow rate.

M. Mitchner, USA

1974. Friedman, R., Kinetics of the combustion wave, *J. Amer. Rocket Soc.* **23**, 6, 349–354, 374, Nov.-Dec. 1953.

A comprehensive review article, mainly for nonspecialists in this field, indicates the present-day position in the theory of the combustion wave. The Hugoniot relation is derived and used to indicate the difference between detonation and deflagration (normal burning velocity) processes. Next, the Mallard-le Chatelier equation for the normal burning velocity is derived and its limitations indicated. A simplified version of the Hirschfelder-Curtiss theory for a first-order reaction is given and discussed and the results of some experimental determinations of burning velocities indicated and compared with theory. The structure of the deflagration wave is also discussed and methods for the determination of the temperature distribution within it are indicated. The factors affecting the stability of the deflagration wave are briefly mentioned. Reviewer is of the opinion that the value of this article would have been enhanced by a description of the methods used for the determination of burning velocity. There are 33 references. A. H. Howland, England

1975. Campbell, E. S., and Hirschfelder, J. C., Review of the reaction kinetics and transport properties of a hydrogen bromine flame, *Univ. Wisc. Nav. Res. Lab.* CF-2108, 58 pp., Nov. 1953.

Theoretical calculations on hydrogen-bromine flames are now being conducted. This review of the kinetics and transport properties of the chemical components of the flame has been undertaken both to determine the best set of physical parameters and to obtain an idea of the limit of significance of the computations. The effect on the calculation of varying the experimental parameters within the limits of their accuracy gives a necessary check on the significance of a theoretical result. This requires assignment of rough limits to the uncertainty which arises from (a) conflicts in the necessary extrapolation of experimental data, and (b) the estimation of physical properties when no data are available. Other available reviews did not seem to delineate the extent of the controversies and therefore provided neither a basis for selecting between discordant experimental values nor for estimating the resultant uncertainties.

From authors' summary

1976. Campbell, E. S., Hughes, D. R., and Buehler, R. J., Equations for a hydrogen-bromine flame: computational methods and techniques, *Univ. Wisc. Nav. Res. Lab.* CF-2109, 146 pp., Oct. 1953.

The quest for the numerical solution of the hydrogen-bromine flame equations has led to the solution of a problem of far more general interest: A general computational procedure for the construction of Taylor series developments for the variables of a simultaneous set of first-order ordinary differential equations subject to (a) either of two general classes of bounda[ry] conditions, (b) restrictions on the nature of the functions. These restrictions are frequently satisfied in equations met in applied work.

In the past, other methods of numerical integration than the series approach have been favored because of the generally formidable labor required to construct successive derivatives. The proposed computational techniques lessen both the formal and the computational labor required in the construction. Since the problem has been considered in terms of its mathematical essentials and a moderate generality sought, the notation ap-

pears formidable; nevertheless, it provides a simple key to special cases. The practical advantage of the proposed procedure has been proved. Thus, long hours of clever juggling were required to select currently used computational directions for the hydrogen-bromine flame equations in preference to others which required vastly more labor. Nevertheless, the computational theory outlined in this report suggests a somewhat simpler procedure. This is achieved straightforwardly with a minimum of juggling. To clarify the general notation and to illustrate the procedure, the method is applied specifically to the hydrogen-bromine flame equations.

Although the series method in general still requires more labor than several of the traditional methods, the latter are not always applicable. For example, in the vicinity of the "hot boundary" the occurrence of disastrous subtraction limits the applicability of traditional point-by-point methods to the hydrogen-bromine equations. The series approach may also be of value in cases where some other methods allow too great a buildup of truncation and rounding error. Finally, whenever derivatives are desired, the derived series present convenient analytic approximations, and the saving in the labor required to construct derivatives by difference techniques may more than compensate the added labor required to form the series solution to the differential equations.

Other numerical problems which have been met in the course of this study are discussed. While the points considered are not deep, they are important for the routine of the calculation. Special mention might be made of the proposed notation for the construction of the principal minors of a determinant. This notation serves to emphasize the basis of the method and simplifies its proof.

Finally, the differential equations, the functional forms assumed for the kinetic and the transport properties, and the boundary conditions which are employed in the current study of a one-dimensional, steady-state hydrogen-bromine flame are reviewed; the values of the numerical parameters are tabulated.

From authors' summary

1977. **Behrens, H., Combustion and gasification of carbon in chain reaction** (in German), *Brennstoff-Wärme-Kraft* **5**, 8, 272–275, Aug. 1953.

Nonmathematical review of current concepts of solid carbon oxidation. Various reaction schemes are shown and the roles of hydrogen atoms, oxygen atoms, and hydroxyl radicals in perpetuating chain reactions are discussed. Two-stage carbon oxidation going first to carbon monoxide, then to carbon dioxide is outlined. The catalytic effect of water on carbon-oxidation processes is also discussed. Theories of reaction kinetics reviewed in paper are applied to industrial coal-burning furnaces and coal-gasification equipment to explain furnace behavior and products obtained at different temperatures and operating conditions.

T. P. Clark, USA

1978. **Grossman, P. R., and Curtis, R. W., Pulverized-coal-fired gasifier for production of carbon monoxide and hydrogen,** *Trans. ASME* **76**, 4, 689–695, May 1954.

This paper describes a pilot-plant pulverized-coal gasifier installed at the Morgantown Station of the Bureau of Mines and a semicommercial gasifier of similar design installed at the E. I. du Pont de Nemours Company, Inc., Belle, W. Va. A brief summary of the operating data obtained from these two units is presented and material requirements are given for this method of coal gasification. A large-sized unit of this design is now under construction and will go into operation next year. This will be the first commercial application of the process in this country. Details of the design that provide for handling of coal ash of widely varying fusing temperatures are given in an effort to point out those features which have contributed to continuous uninterrupted operation. Included also is a discussion of heat flow within the gasification unit to illustrate the factors involved in obtaining an economical process.

From authors' summary

1979. **Pouchot, W. D., and Hamm, J. R., Characteristics of a vaporizing combustor for aviation gas turbines,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-182, 10 pp.

The fuel for an annular combustion chamber is fed to the longer limb of a number of U-shaped tubes in which it is evaporated in the presence of primary air (air/fuel ratio about 4 : 1). This effectively prevents the formation of deposits even with a fuel of high gum content. Secondary air ports are situated in the upstream plate and combustion is completed by the air entering through these and through the first two sets of openings in the inner liner. Because the fuel does not have to evaporate in a fast-moving air stream, the combustion zone is 40% shorter than in the conventional spray combustor. The combustion efficiency varies less with variation in fuel-air ratio than in the conventional system and the distribution of exit temperature is better. The fuel supply arrangements are, however, liable to be more complicated as the number of vaporized tubes must be large and auxiliary fuel nozzles are necessary for ignition.

M. W. Thring, England

1980. **Havemann, H. A., A theory of vortex combustion-chamber design: Part I,** *J. Inst. Fuel* **26**, 155, 294–305, Dec. 1953.

This paper is the first part of an analysis of the combustion of fuel droplets as they rotate in an oxidizing atmosphere in a vortex combustion chamber. The dynamical behavior of the drops is based on the action of centrifugal forces and viscous drag forces in the radial direction. It is assumed that there is no slip between the drop and the gas velocity in the tangential direction. The stability of the droplets is investigated, and formulas are presented which describe the dimensions of a combustion chamber in terms of maximum and minimum droplet sizes (the restrictions to these relations are to be found in the unpublished appendixes). If an evaporation law similar to that of Godsave ["Fourth symposium on combusion," Williams and Wilkins Co., 1953, 818–830] is assumed, the radial position of the drop at any time can be found if the velocity field is known. The change in the gas flow due to the combustion is also considered, as well as the effect on drop position of changes in state and composition of the drop (particularly important in the case of mixed base fuels). Unfortunately, many of the more important relationships presented are derived in appendixes which are not to be published and are only available at the Library of the Institute of Fuel (England). This makes it difficult to follow all of the author's reasoning, and one has to accept the results on this basis.

R. S. Wick, USA

1981. **Neat, W. N., Some limiting factors of chemical rocket motors,** *J. Brit. interplanetary Soc.* **12**, 6, 249–274, Nov. 1953.

With the advent of atomic power as a possible form of propulsion of space vehicles, a critical appraisal of the possible capability of the chemical rocket is made. By examining three hypothetical missions—orbital, earth-moon-earth, earth-Mars-earth—criteria are formed which determine the required performance of a rocket for completing each mission. A thermodynamic analysis is then made which reveals the effects of specific heat ratios, the mean-molecular weight of the product of combustion, the expansion ratio, and the combustion temperature on rocket performance. These effects are then discussed in detail with due consideration

of practical difficulties which eventually limit the use of the chemical rocket for each mission. Other factors important in design, such as chamber pressure, cooling, tankage weight, the choice of propellant are also discussed. It is concluded that higher expansion ratio, as compared with the present practice, should be used for future rockets, and that the earth-Mars-earth (and perhaps even the earth-moon-earth) mission will likely remain forever beyond the capabilities of the chemical rocket.

B. T. Chu, USA

1982. **Morrow, C. H., Holton, W. C., and Wagner, H. L., Investigation of gravity reinjection of fly ash on a spreader-stoker-fired boiler unit,** *Trans. ASME* **75**, 7, 1363–1372, Oct. 1953.

Paper confirms previous papers which reported improvement in over-all efficiency by total reinjection of fly ash from boiler and dust collector hopper on a spreader-stoker-fired unit. Since refuse in dust-collector hoppers ran as high as 55% combustible, total reinjection of this refuse resulted in a reduction in the carbon loss of 4.9% and similar improvement in efficiency. This paper also confirms previous data that it is possible to operate a spreader-stoker-fired unit with total reinjection and not exceed the ASME Model Smoke Law. With total reinjection the dust loading was only 0.3 lb of dust per 1000 lb of gas. Excess air was maintained at low values, 16% to 21% at the boiler outlet, and this, coupled with low gas temperature leaving the airheater, resulted in efficiencies ranging from 84.9% without reinjection to 89.4% with total reinjection. The authors credit these results to a newly designed rear stoker seal, gravity feed of dust collector, fly ash, and combustion-control system. Lack of airheater plugging and corrosion is also credited to the method of gravity reinjection and total reinjection, but attention should also be called to the high air temperatures entering the airheater, 128° to 136°, which will have a large influence on eliminating such air-heater difficulties.

The paper presents very complete data on analyses of fly-ash samples, both as to size and combustible content of the various size fractions.

E. F. Rothemich, USA

1983. **Allen, J. M., An investigation of the burning characteristics of pulverized cinders,** *Trans. ASME* **75**, 7, 1333–1337, Oct. 1953.

Investigation was part of program to reduce cinder emission from locomotives, especially to find a method of disposing of collected cinders. Particular objective was to determine degree of completion of burning of pulverized cinders as function of residence time in firebox. Variables were fineness of pulverization, temperature in firebox, and excess air supplied. Method involved burning cinders in a laboratory test furnace under known conditions and sampling to determine burning completion as function of residence time. Burning completion was increased by increase in fineness of pulverization and by increase in furnace temperature for normal condition of 25 to 30% excess air. Preheating to 600 F had little effect on ultimate degree of completion of burning.

Marjorie W. Evans, USA

1984. **Kantorovich, B. V., Theory of heterogenic combustion and gasification of a stream of fuel** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **89**, 3, 463–466, Mar. 1953.

This short note is intended for design calculations of such items as stokers and gas turbines.

The flow of fuel is considered as a continuous and at the same time discontinuous medium, consisting of homogeneous particles. With the use of energy equation, the fundamental characteristics of the dynamics of this flow are obtained as functions of such variables as temperature, mass velocity, specific heat, heat content, specific weight, initial velocity, relative radius of particles, and hydraulic radius of the combustion cross section.

L. M. Tichvinsky, USA

1985. **Cashmore, W. P., and Thring, M. W., Experiments on flame radiation in an empty open-hearth furnace,** *J. Iron Steel Inst. Lond.* **175**, 2, 177–182, Oct. 1953.

The effect of changing the flame conditions on the radiation along the flame in an empty 100-ton furnace maintained in a steady state is reported. It was found that steam quality had a large effect, the over-all radiation being 7% higher when slightly superheated steam was used for atomization than when 0.85 dry steam was used. Colder oil with higher steam quantity and hotter oil with lower steam quantity gave 6% more radiation than the reverse conditions, implying that the optimum steam/oil ratio rises when the oil viscosity increases. Air preheated to 1000 C doubles the peak radiation, owing to an effective increase in flame temperature from 1200 C to 1600 C.

J. E. Brock, USA

1986. **Codegone, C., The radiation from flames** (in Italian), *Termotecnica* **9**, 9, 363–368, Sept. 1953.

Radiation between a flame and its enclosing wall is treated; the case for the nonuniform wall temperature is included among the usual applications presented.

M. J. Goglia, USA

1987. **van Stein Callenfels, G. W., International flame-radiation research at Ijmuiden,** *Engineering* **176**, 4579, 555–556, Oct. 1953.

Author describes organization and nature of research performed at Ijmuiden in the Netherlands. National committees representing ceramic, fuel-oil, gas, boiler-making, and other industries in each of six countries sponsor programs directed by an International Joint Committee. Research concentrates on combustion and heat transfer from luminous flames, probing the complex interaction of combustion rate and mechanism, mixing rates, gas dynamics, and temperature. While small-scale studies of certain aspects of the problem are made at sites in several countries, difficulty of scaling results requires large-scale work, which is performed at Ijmuiden with a furnace 2 × 2 × 7.5 m. Furnace accommodates a variety of burners and has vertical sight-slots for radiation pyrometry.

Both applied and fundamental combustion-mechanism experiments are performed. Examples of results of the former are those showing that, with a given liquid fuel, flame radiation can be correlated with burner backthrust and nozzle size only, for any steam- or air-atomizing burner; quantitative measurements show the radiation increase from addition of liquid fuel to a gas flame. A newly constructed furnace will permit use of preheated combustion air and investigation of high-temperature phenomena.

Work at Ijmuiden is a refreshing example of open research openly published, performed cooperatively by men from several nations.

W. P. Jensen, USA

1988. **McIlroy, J. B., Holler, E. J., Jr., and Lee, R. B., The application of additives to fuel oil and their use in steam-generating units,** *Trans. ASME* **76**, 1, sect. 1, 31–42, Jan. 1954.

Problem of ash formation in oil-fired steam-generating plant is considered. This ash may be deposited on heat-transfer surfaces as a fused mass which is difficult to remove, especially if ash contains a high proportion of low M. P. constituents. Authors describe effect of certain additives to fuel oil to increase M. P. of ash

and to render it easily removable. Preliminary firing temperature and furnace tests indicated that alumina followed by magnesia or calcium oxide were the most effective additives. Further tests with alumina in a full-sized steam-generating plant confirmed these results, but it was later found that dolomite added in the proportion 1:1 by weight compared with ash content of fuel was both more effective and economical in use. It was noted that dolomite tended to reduce air-heater corrosion, possibly by reduction of free sulphur-trioxide content of flue gases. This aspect of the work, however, was not investigated fully.

A. H. Howland, England

1989. **Biert, J., and Scheidegger, R., Failure of gas turbine plants through corrosion of materials due to the ash of the fuels** (in German), *Schweiz. Arch.* **19**, 12, 359–366, Dec. 1953.

1990. **Bell, W. C., Hart, J. R., and Gower, I. W., Slagging of navy boiler refractories,** *Engng. School Bull. N. Carolina St. Coll.* no. 58, 46 pp., July 1953.

Sodium sulphate is often formed in marine boilers as a result of salt water in the fuel, and this paper discusses the resistance of various refractories (including various high-duty and superduty fire-clay bricks, semisilica and pyrophyllite firebricks, fused mullite, high alumina, and basic refractories and refractory cements) to slagging by this compound. A simulated service test is described in which sodium sulphate is dripped onto and allowed to flow down an inclined test specimen (2 ft $5^1/_2$ in. × 1 ft 6 in.) installed in an oil-fired furnace at temperatures of 2600 and 2800 F. The slagged panels were visually examined and photographed after a 5-hr test period.

Significant slag attack was observed in all tests except those in which basic or neutral refractories (i.e., chrome, magnesia) were used. Many more highly refractory materials (i.e., some high alumina and bonded, fused mullite compositions) showed poor resistance to attack, while several super- and high-duty fire-clay bricks showed superior slag-resistance properties. The most critical point of attack in all cases was the mortar joints. Attack in the bricks themselves was mostly between the slag and the bond or fine fraction; and the porosity of the refractory (measured as "apparent porosity" rather than by air permeability) was found important. It was apparent that the structure and properties of the bonding medium of the refractory were significant, though no examination of the chemical and physical properties of these constituents or the products resulting from the reaction are reported.

G. G. Thurlow, England

1991. **Taylor, B., and Booth, H., Service performance of boiler brickwork—the causes and extent of wastage,** *Trans. Inst. mar. Engrs.* 65, 7, 165–179, 6 plates, July 1953.

Acoustics

(See also Rev. 1950)

1992. **Garrick, I. E., and Watkins, C. E., A theoretical study of the effect of forward speed on the free-space sound-pressure field around propellers,** *NACA TN* 3018, 39 pp., Oct. 1953.

The sound-pressure field of a rotating propeller in free space is analyzed by replacing the normal-pressure distribution over the propeller associated with thrust and torque by a distribution of acoustic pressure doublets acting at the propeller disk and subject to uniform rectilinear motion. The basic element used to synthesize the field is the pressure field of a concentrated force moving uniformly at subsonic speeds. The result is presented for the moving and for the fixed observer. Some illustrative examples are calculated and discussed.

R. C. Binder, USA

1993. **Chase, C. E., Ultrasonic measurements in liquid helium,** *Proc. roy. Soc. Lond.* (*A*) **220,** 1140, 116–132, Oct. 1953.

A pulse technique has been used to measure the velocity and attenuation of ordinary sound in liquid helium at frequencies of 2, 6, and 12 mc/s, over the temperature range from the normal boiling point down to 0.85 K. A variable path method increased the accuracy of the velocity measurements over those previously reported since it was no longer necessary to know the absolute separation. Particular attention has been paid to the attenuation in the neighborhood of the λ-point and in the very low temperature region. The attenuation is found to be very high near the λ-point and at low temperatures, and is proportional to ω^2 between 1.2 K and the λ-point. The value of the attenuation near the λ-point favors the very short relaxation time (less than 10^{-12} sec) of the Kronig theory. At lower temperatures, a change in the frequency dependence is observed, indicating the presence of a relaxation effect. The large attenuation at low temperatures is thought to be associated mainly with the phonon-roton relaxation of the Khalatnikov theory, while the phenon-phenon relaxation of the same theory is coming into play below 0.95 K.

J. L. Stewart, USA

1994. **Pancholy, M., Temperature variation of velocity and absorption coefficient of ultrasonic waves in heavy water** (D_2O), *J. acoust. Soc. Amer.* **25,** 5, 1003–1006, Sept. 1953.

The coefficient of absorption, velocity of propagation, and adiabatic compressibility of D_2O is measured at a frequency of 50.22 mc/sec for temperatures ranging from 5 to 50 C. The results obtained for these parameters is qualitatively similar to that obtained in H_2O. The experimental value of the absorption coefficient, found to be always larger than the value in H_2O at the same temperature, is larger than the theoretically calculated value by a factor of about 2.9 for the temperature range considered. The velocity of propagation is found to be about 100 ms/sec less than in H_2O. Possible theoretical reasons for the high values of attenuation are discussed.

M. S. Weinstein, USA

1995. **Martin, E., and Werner, K., Testing of machine parts of complicated geometry with ultrasonics** (in German), *Arch. Eisenhüttenw.* **24,** 9/10, 411–422, Sept./Oct. 1953.

The testing of railway axles with ultrasonic pulses is done by transverse sonic waves with oblique incidence. Discussion of the oblique incidence method leads to a distinction between cracks oblique to the axis and faults originating from corrosion pits. Incidence angles of 30° to 57° are also used in multiple reflection testing. This method only permits discovering surface cracks. Brasses, too, are tested with pulses by means of a special plexiglas transducer.

Rolled shrinkages, transverse ruptures, etc., in rails are detected from the upper surface by theoretical investigations of the rail geometry, which also enable the detection of welding faults in the foot of the rails. The acceptance test of the rails is too costly, but ultrasonic pulses are highly suitable for testing particularly sensitive parts, such as weldings.

O. Ruediger, Germany

1996. **Corliss, E. L. R., and Burkhard, M. D., A probe tube method for the transfer of threshold standards between audiometer earphones,** *J. acoust. Soc. Amer.* **25,** 5, 990–993, Sept. 1953.

To establish threshold standards for various types of earphones, from a set of threshold standards that has been determined for one particular type of earphone by a hearing survey, an empirical relationship must be found giving the sound pressures in the calibrat-

ing coupler corresponding to equal sound pressures in the ear. This has previously been accomplished by means of loudness balancing between earphones. The method described in this paper makes use of a direct probe measurement of the sound pressure developed by an earphone at the entrance to the ear canal. The experimental process is described and the results of tests to establish the equivalence of the probe method and loudness balancing are given. In addition, several of the conditions under which loudness balancing is carried out were investigated by the probe method. Equal loudness sensation was found to correspond to equal sound pressures at the ear, within the limits of experimental error. From authors' summary

Although the probe method for transfer of threshold standards is easier to carry out than loudness balancing, it is necessary with either method to make a transfer for each new type of earphone. Thus each time the design of earphones is changed, a number of human subjects must be assembled and a transfer of standards must be made. If a coupler that terminates earphones with the appropriate acoustic load can be made, it will be possible to make direct comparisons of earphones.

W. C. Johnson, Jr., USA

1997. Nyborg, W. L., Acoustic streaming equations: laws of rotational motion for fluid elements, *J. acoust. Soc. Amer.* **25,** 5, 938–944, Sept. 1953.

The author's main contribution consists in identifying the third-order differential equations commonly used in acoustic streaming with the law of rotational motion for a spherical element of fluid and in explaining the significance of its various parts. Author seems to be influenced by Broadwell's recent discussions on the rotational motion of a small square element of fluid participating in aerodynamic flow. G. S. Verma, India

1998. Andres, J. M., and Ingard, U., Acoustic streaming at low Reynolds numbers, *J. acoust. Soc. Amer.* **25,** 5, 932–938, Sept. 1953.

Paper discusses an analysis of acoustic streaming around a cylinder for low Reynolds numbers (order of ten), extending the previous analysis for high Reynolds numbers published by the same authors [title source **25,** p. 928, 1953]. It is shown that the flow pattern obtained around a cylinder in a sound field for low Reynolds numbers is opposite to the one corresponding to high Reynolds numbers. The theoretical results conform to existing experimental results in the literature. If a large number of photographs near the state of transition between the two types of flow for various dimensions of the cylinder are available, they will be of great interest and may throw more light on the critical value of Reynolds number. G. S. Verma, India

1999. Pritchard, R. L., Optimum directivity patterns for linear point arrays, *J. acoust. Soc. Amer.* **25,** 5, 879–891, Sept. 1953.

Author summarizes the method of C. L. Dolph and H. J. Riblet of calculating the equal-minor-lobe directivity patterns for arrays of 5–13 odd numbers of equally spaced point elements. He investigates and discusses numerically the effect of spacing of the elements (spacing greater and less than a half wave length), the relationship existing among angular width of the major lobe, relative amplitude of the equal-minor-lobes, directivity index, and, finally, extends the method to compensated or steered arrays.

From author's summary by K. Pohlhausen, USA

2000. Schwartz, D. S., and Russo, A. L., Schlieren photographs of sound fields, *J. appl. Phys.* **24,** 8, 1061–1062, Aug. 1953.

2001. Ording, J. R., and Redding, V. L., Sound waves observed in mud-filled well after surface dynamite charges, *J. acoust. Soc. Amer.* **25,** 4, 719–726, July 1953.

An array of three pressure pickups 100 ft apart covering a vertical range of 200 ft was used to record sound waves in two wells drilled to depths exceeding 12,000 ft. Dynamite charges were exploded in 80-ft holes at a distance of 500 ft from the well head. A separate charge was fired with the array at each 500-ft interval in the well. The recorded events were analyzed and found to belong to two categories. The first category includes the pressure pulse arriving at the pickup by a more or less direct route through the sedimentary rocks. The second consists of events set up in the midcolumn at points other than adjacent to the pickup by the compressional wave in the sedimentary rocks. These events then travel through the mud column and are recorded as they pass the pickup. Anomalies in the hole, such as the ends of casing strings and the bottom of the hole, cause events of larger amplitude than those set up in sections of the hole with no major anomalies.

From authors' summary by F. G. Blake, Jr., USA

Soil Mechanics, Seepage

(See also Revs. 1779, 1780)

2002. Penman, A. D. M., Shear characteristics of a saturated silt, measured in triaxial compression, *Géotechnique, Lond.* **3,** 8, 312–328, Dec. 1953.

In the past, triaxial tests on silts gave no clear indication whether these soils were cohesive or frictional, because only total stresses were measured. This prevented interpretation and application in terms of effective stresses to field drainage conditions.

Author made consolidated-drained and consolidated-undrained tests on clay-free inorganic coarse silt, at various densities and test pressures. Consolidation pressure for undrained tests was 5 psi. Volume changes were measured and a servo-operated gage measured pore-water pressures in undrained tests without appreciable volume changes. Friction of wet and dry quartz surfaces was measured for comparison.

Drained tests showed expansion during shearing and indicated decrease of ϕ with increasing voids-ratio or lateral pressure. Undrained tests showed corresponding fall in pore-water pressure, controlled by voids-ratio and lateral pressure. Above critical lateral pressure, silt behaves as $\phi = 0$ material to total stresses; below critical pressure, as c, ϕ material due to gas liberation in pores. Latter condition probably applied in early routine silt tests.

Author's use of mean effective pressure in Taylor's interlocking (energy) correction is invalid; lateral pressure should be used instead [Bishop and Eldin, AMR **6,** Rev. 3929]. If valid correction is applied to drained test results given, variation of ϕ_d with voids-ratio is greatly increased.

Reviewer feels any true cohesion present in silt used would be masked by author's use of equivalent friction angles to express results. This procedure is suitable only for completely cohesionless soils. Value of paper would have been enhanced by comparison of friction between drained and undrained tests, also by inclusion of Mohr envelopes for total and frictional forces in drained tests.

T. K. Chaplin, England

2003. Higashi, A., On the thermal conductivity of soil, with special reference to that of frozen soil, *Trans. Amer. geophys. Un.* **34,** 5, 737–747, Oct. 1953.

Using the Ångstrom principle, a new apparatus for measuring

the thermal diffusivity of soil was designed. In order to give the sinusoidal boundary conditions, the apparatus was constructed to change the applied voltage of a heater. A simple autotransformer and a special cam were used for this purpose. Using this apparatus, the thermal diffusivity of frozen soil as well as wet soil was measured. From author's summary

2004. **Drucker, D. C., Limit analysis of two- and three-dimensional soil mechanics problems,** *J. Mech. Phys. Solids*, **1**, 4, 217–226, July 1953.

The author extends work of earlier paper [AMR **6**, Rev. 299] on the implications of assuming soil to be a perfectly plastic body. Coulomb's equation is interpreted in terms of a modified Tresca as well as a modified Mises criterion, and consideration is given to a soil unable to take tension. Upper bound solution to stability of vertical bank obtained in earlier paper is improved upon, and some indication of the power of the limit theorems is given by the solution of a problem involving inhomogeneous clay. Author emphasizes that ". . .answers obtained are correct for material postulated but may have no relevance to any actual material." Reviewer believes that with brittle (high E/c) undrained clays ($\phi = 0$), assumptions of the theory are acceptable. With sands ($c = 0$), however, the theory shows that rate of internal dissipation of energy is zero, which is untenable unless coefficient of friction between sand grains is zero. This implies that the angle of friction ϕ of the theory is a measure only of the dilatancy rate and not of internal friction, and that, with loose sands, ϕ will be negative or, at best, zero.

R. E. Gibson, England

2005. **Kleĭn, A. L., Steady affluence of fluids and gases to incomplete wells** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* 91, 2, 213–216, July 1953.

2006. **D'Appolonia, E., Miller, C. E., Jr., and Ware, T. M., Sand compaction by vibroflotation,** *Proc. Amer. Soc. civ. Engrs.* 79, Separ. no. 200, 23 pp., July 1953.

2007. **Gibson, R. E., and Lumb, P., Numerical solution of some problems in the consolidation of clay,** *Proc. Instn. civ. Engrs.* **2**, 2, 182–198, Mar. 1953.

Paper presents several comparisons between a step-by-step finite difference solution of soil consolidation and exact mathematical solutions. The two approaches are in good agreement, and the numerical method permits solutions for two- and three-dimensional consolidation. Paper also presents applications of the numerical method to consolidation beneath a circular footing and in clay cores of earth dams. The procedure offers possibilities for solution of consolidation of clays having complicated boundary conditions and drainage paths. J. A. Cheney, USA

2008. **Nascimento, U., Capillarity and soil cohesion,** *Minist. Obras Públ., Lab. Engen. civ. Lisboa Publ.* no. 37, 13 pp., 1953.

2009. **Gibson, R. E., Experimental determination of the true cohesion and true angle of internal friction in clays,** *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, vol. I, 126–130.

Drained shear tests carried out on six remolded and two undisturbed clays with the object of examining the validity of the Coulomb-Hvorslev criterion of failure are described. The true cohesion and true angle of internal friction are defined and a failure criterion based upon energy considerations is tentatively proposed. This criterion retains the mathematical structure of Hvorslev's equation, but the meaning of the fundamental parameters is altered.

These true cohesion and true angle of internal friction parameters are evaluated from the results of the drained shear tests, the latter parameter being compared with its value as obtained by measuring the inclination of the failure planes in undrained compression specimens.

From author's summary by A.-T. Yu, USA

2010. **Jiminez Salas, J. A., and Serratosa, J. M., Compressibility of clays,** *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, vol. I, 192–198.

Authors have contributed a useful article emphasizing the important effect of physico-chemical factors on the mechanical properties of soils. They have carried out research on two extreme soil types, viz., kaolin and bentonite, with five different exchange cations and also have investigated the effect of mixing bentonite with various organic liquids. The main conclusions obtained from the results of the authors' experiments are that the compressibility of a particular clay varies with the adsorbed cation directly as the hydration capacity, and that when different organic liquids are admixed, the compressibility varies directly as the polar moments of the liquids used, the consolidation being almost totally secondary in the latter case. In view of the important physico-chemical effects on compressibility, the authors offer a new theoretical approach to the problem based on the well-known Freundlich diagram. The results of the experiments are in general agreement with past work in this field.

S. G. Samuels, England

2011. **Peltier, R., Contribution to a theory on capillary action in the freezing of road soils** (in French), *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, vol. II, 128–132.

In certain soils a large increase in water content (up to 200 to 300%) occurs on freezing. On thawing, a serious deterioration of mechanical properties may result. Author explains the phenomenon by capillary attraction of water from deeper layers into the layer where freezing of adsorbed water films takes place. A theoretical treatment of a much simplified case is given. The amount of water attracted by the freezing layer appears to be—as far as it depends on soil properties—proportional to square root of $Khn/(h_0 + h)$, where K is water permeability of soil, n its porosity, h the height of the capillary zone, and h_0 a constant ($h_0 \gg h$). It follows that loam soils show the phenomenon in particular. The theory is supported by laboratory experiments. Preventive measures in road construction are suggested. Although author describes an apparatus used in an experimental verification of his theory and states that such a verification will be presented, the experimental results are missing. D. A. de Vries, Holland

2012. **Post, G., and Londe, P., Rolled fill earth dams. American practice [Les barrages en terre compactée. Pratiques Américaines],** Paris, Gauthier-Villars, 1953, 185 pp.

This is a condensed but precise summary of on-the-spot observations by the authors during a year's study in the United States of the techniques employed by U. S. Army Engineers, Tennessee Valley Authority, New York City Water Supply Board, U. S. Bureau of Reclamation, and Los Angeles City Department of Water and Power.

The first chapter (54 pp.) covers fundamentals and techniques of relevant soil studies—compaction, settlement, permeability, shearing resistance, classification. The second chapter (64 pp.) describes design procedures, selection of materials and type of dam, spillways, slope protection, flow nets, discharge, seepage

forces, piping, slope-stability computations. The third chapter (8 pp.) deals with stability and imperviousness of foundations. The fourth chapter (32 pp.) describes construction procedures—selection and operation of borrow pits; transportation, spreading, and compaction of fill materials; preparation of foundations; field control tests, and pore-pressure and settlement measurements. 71 well-chosen illustrations enhance the value of the book.

G. P. Tschebotarioff, USA

2013. Reese, L. C., Matlock, H., and Dawson, R. F., Load distribution along a model bearing pile, *Univ. Texas Circ.* 20, 17 pp., 1953.

THE FOLLOWING PAPERS (Revs. 2014–2019) WERE PUBLISHED IN *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, in 3 vols. 75 SFr per set. (See also Revs. 2009–2011.)

2014. Tettinek, W., and Matl, F., A contribution to calculating the inclination of eccentrically loaded foundations, vol. I, 461–465.

The paper attempts to give formulas for the inclination of the surface of contact between an eccentrically loaded member and the soil. The calculations are based upon Boussinesq's solution for the vertically loaded semi-infinite elastic body. They may, for the cases dealt with (circle, rectangle, infinitely long strip), give a rough idea of the magnitude of the inclinations to be expected, although it is unlikely that the assumptions (infinitely flexible plate to transmit the load and nevertheless linear distribution of stresses of contact) are fulfilled in practical cases.

K. Marguerre, USA

2015. Cuadrat, S. M., Piles driven in-situ under compressed air (in French), vol. II, 37–40.

2016. Golder, H. Q., Some loading tests to failure on piles, vol. II, 41–46.

2017. Bernard, P., Measurement of moduli of elasticity and their application to the design of pressure tunnels (in French), vol. II, 145–156.

Author describes a series of tests executed in a tunnel of 17-km length in the neighborhood of Casablanca. The scope of tests was to get information on the actual values of the moduli of elasticity in the various substrata surrounding the tunnel, which was intended to be dressed with but a thin internal lining. Therefore, it was essential to study the effect of cement grouting, how much support it afforded the lining by filling the occasional voids and thus securing a cooperation between the surrounding rock and the lining itself.

The first series of tests was carried out with hydraulic jacks in the 5.3-m (17.5-ft)-diam tunnel. Three types of rock were tested: (a) Compact rocks not subject to strain; (b) fissured rocks with high plastic strain; (c) soft rocks with lateral failure under low pressure.

The stresses were calculated by the formula: $\sigma_t = p/[(d/R) + (E_B/E_R)]$ where σ_t = tension stress in the lining, p compression on the tunnel, d thickness of wall, R radius of section, E_B modulus of elasticity for the concrete, E_R modulus of elasticity (deformation) for the rock.

It was stated that the minimum values of deformation moduli were always obtained when the rock was stressed rectangularly to its stratification and its value increased essentially by the number of loading cycles. It was stated, however, that in fissured rocks the jacks did not deliver reliable results and therefore the tests were completed by stress-strain measurements in adjoining 2.3-m (8-ft)-diam testing galleries. Three diametrically laid testing rods were placed in each section of the gallery and in each of them an acoustic stress-strain cell (Coyne type) was inserted. In addition, circumferential cells were also placed along the perimeter. By means of these cells the effect of grouting and its radius of action was also checked.

It was found that the deformation modulus was materially increased by cement grouting (more than doubled) and its value was not less than 50,000 kg/cm² (700,000 psi).

It is to be regretted that the diagrams and observations are used merely for general conclusions and no theoretical statement made on the basis of these important tests; also that no method is given for practical calculations. The tabulated numerical values of deformation moduli are only of informative value.

C. Széchy, Hungary

2018. Barron, R. A., The efficacy of toe drains in controlling seepage uplift in layered pervious foundations, vol. II, 195–197.

Mathematical solutions are obtained for the problem of seepage through a two-layered pervious foundation, covered by an impervious top blanket, to a semicircular toe drain. For cases where the lower pervious layer is somewhat more pervious than the upper pervious layer, the efficacy of the drain is seriously reduced.

From author's summary by H. Lundgren, Denmark

2019. Verdeyen, J., and Roisin, V., Shutting of excavations; methods of calculating flexible bulkheads (in French), vol. II, 188–192.

Construction of the subway connecting Nord and Midi stations in Brussels by the cut-and-cover method required an extensive system of transverse bracing. The authors were able to measure the force on the streets and relate the degree of conformity of their method of calculation to several other methods in contemporary use. Article is a good review of current methods. It would have been better had they described in more detail the method of measuring the forces in the streets.

K. N. Hendrickson, USA

Micromeritics

(See also Revs. 1862, 2006)

2020. Brown, R. L., Mixing of granular materials, *Research Lond.* 6, 11, 57S–58S, Nov. 1953.

Brief note suggesting a method of analyzing data relating to the mixing of granular materials. The idea elaborated by Danckwerts [title source, 6, p. 355, 1953] is considered as the first step in the qualitative description of a mixture of granular materials. On this basis a "hypothetical" experiment in the study of mixing was carried out with a pack of cards. With present absence of practical data it is too early to adopt the suggested approach as the only method of analyzing data relating to mixes. Experiments are in progress to seek other methods.

S. R. Faris, USA

2021. Shergold, F. A., The percentage voids in compacted gravel as a measure of its angularity, *Mag. Concr. Res.* no. 13, 3–10, Aug. 1953.

For a gravel pack compacted in a standard fashion a method is described for expressing the angularity of the gravel in terms of the percentage voids of the pack. Angularity is expressed in terms of the "angularity number" which is given by

$$\text{angularity number} = \text{percentage voids} - 33$$

Twenty-seven references provide a very comprehensive bibliography on the subject discussed. S. R. Faris, USA

2022. **Holton, W. C., and Schulz, E. J., Some notes on dust-sampling equipment and technique,** *Trans. ASME* **75,** 7, 1327–1331, Oct. 1953.

Battelle Memorial Institute was introduced to the problem of dust sampling in connection with research on the combustion of pulverized coal 20 years ago. The special techniques and equipment needed for stack sampling were first developed in connection with a research investigation on spreader stokers. Subsequently, they have been elaborated and refined in various research investigations where dust measurements were needed. The equipment described has been used for dust sampling of flue gas from spreader stokers, pulverized-coal burners, and locomotives and covers a wide range of sizes of plants. This paper summarizes the results of the work at Battelle and is presented in the hope that others may be helped by a study of this experience. It is also hoped that desirable modifications in the equipment or technique may be suggested by those reading this paper.

From authors' summary

2023. **Das Gupta, A. K., Shrikhande, K. Y., and Khosla, R. R., Pneumatic transportation of coal: Studies in pressure drop,** *J. sci. indust. Res. India* **12,** 10, 496–500, Oct. 1953.

Friction loss, a critical factor in the pneumatic transportation of solids through pipe lines (small diameter), has been investigated for coal transportation. The results of experiments carried out with coal of two different size ranges in a steel pipe (14 ft high and $^7/_8$-in. internal diameter), employing different solid feed and air flow rates, have been correlated by an empirically modified version of the Fanning equation

$$\Delta p_s/L = 2f_s\rho_1 u_s^2/5.2gD$$

A fairly constant value for the "modified friction factor" (f_s) has been observed. From authors' summary

2024. **Findlay, J., The application of conveyors to the handling of materials in bulk,** *Trans. Instn. Engrs. Shipb. Scot.* **97,** 3, 153–200, 1953–1954.

Geophysics, Meteorology, Oceanography

(See also Revs. 1784, 1931)

2025. **Gossard, E. E., The effect of wind on nighttime radiational cooling,** *Trans. Amer. geophys. Un.* **34,** 6, 841–848, Dec. 1953.

Existing theory is simplified by assuming that, in absence of significant condensation, (1) diffusive flux of heat from soil and atmosphere is constant throughout night, and (2) flux of heat is constant below a certain finite height, which increases through night. Author finds results to be in good accord with more exact theory of Jaeger and Knighting and with observations in Texas, provided factors such as cloudiness and condensation do not interfere. K. E. Bullen, Australia

2026. **Saucier, W. J., Horizontal deformation in atmospheric motion,** *Trans. Amer. geophys. Un.* **34,** 5, 709–719, Oct. 1953.

Horizontal fluid deformation is a basic linear property of motion appearing in two forms: stretching and shearing deformation. The resultant deformation rate, and direction, are found by rotating the coordinates through an angle dependent upon the relative values of the two primitive types of deformation in the initial coordinates. Several methods for measuring horizontal deformation in the wind field are introduced and discussed. These employ arbitrary Cartesian coordinates, the latitude-longitude grid of the earth, the local north-south kinematic directions, and the area outlined between three observation points. The field distribution of deformation for an actual wind field is represented by two methods: (1) by scalar patterns of direction and of rate of deformation, and (2) by a vector method at selected points. The geostrophic deformation is obtained graphically from the geometry of pressure pattern. The field distribution of deformation is illustrated for several hypothetical pressure patterns simulating common conditions. From author's summary

2027. **Priestley, C. H. B., Buoyant motion in a turbulent environment,** *Austral. J. Phys.* **6,** 3, 278–290, Sept. 1953.

Solutions are given of the simultaneous equations for the vertical current and temperature of an element of fluid under buoyancy and subject to continuous mixing of heat and momentum with its environment. Verification of a formula for the period of large cloud tops oscillating in a stable layer is given.

H. Arakawa, Japan

2028. **Inoue, E., A preliminary note on the atmospheric turbulent diffusion over rough surfaces,** *J. meteor. Soc. Japan* **31,** 1–5, Jan. 1953.

Theoretical treatment of influence of surface roughness on atmospheric turbulent diffusion, characterized by velocity and period of the largest "turbulon," author's notation for effective eddy. Author compares theoretical result with that of Sutton, who dealt with same problem using macroviscosity as a measure of surface roughness. Major difference in the two approaches involves assumptions regarding height and time variations of the Lagrangian correlation coefficient. Experimental verification of author's findings is not given; however, limited experimental data indicate that Sutton's results are not only of correct functional form but give values of the correlation coefficient and of eddy viscosity in fair agreement with observations.

K. H. Jehn, USA

2029. **Hollmann, G., and Reuter, H., Accuracy of different approximations for the horizontal wind component** (in German), *Tellus* **5,** 3, 403–412, Aug. 1953.

Three theoretical approximations to the true horizontal wind are tested by comparison with true theoretical winds derived from a few simple models. These approximations are (1) the familiar geostrophic wind, (2) a Rossby approximation for stationary wind fields, and (3) a second geostrophic wind approximation attributed to Phillip. A fourth approximation due to Hollmann, also based on a stationary wind pattern, is described and is shown to possess the property that its geostrophic wind component is directed perpendicular to the isogons.

While such theoretical studies have their place in meteorology, greater value will be derived from a test of the above approximations against observed winds. L. Machta, USA

2030. **Kuo, H. L., The stability properties and structure of disturbances in a baroclinic atmosphere,** *J. Meteor.* **10,** 4, 235–243, Aug. 1953.

The perturbation equations for baroclinic zonal flow are made quasigeostrophic by putting the ageostrophic wind proportional to the acceleration of the geostrophic wind, the vertical velocity is made a quadratic function of pressure, and the effect of horizontal and vertical advection of temperature on the stability of waves of various lengths is discussed. The vertical advection

has a stabilizing influence on all wave lengths, which is most important for the shorter ones and cancels the instability due to horizontal advection when the disturbance reaches its maximum intensity.

Waves are classified broadly into very long planetary waves, which are essentially an upper level phenomenon, and the short "surface waves," contained mainly in the lowest levels. The tilt of the phase with height and latitude is discussed.

Unfortunately, reference is frequently made to Kuo's other papers (published and unpublished) and to similar conclusions reached by other authors—which makes reading difficult as the paper is so condensed. The time is probably ripe for a monograph on baroclinic waves, in which notation can be standardized and which can serve as a text for students.

R. S. Scorer, England

2031. Arakawa, H., On the maintenance of westerlies and tropical revolving wind systems, *J. meteor. Soc. of Japan* (2) **31,** 6, 1–11, June 1953.

Work is divided into four principal sections. In the first, author expresses equations of mean motion, continuity, and energy in generalized orthogonal curvilinear coordinates. In the second section, these equations are written in terms of cylindrical and spherical coordinates.

The third section demonstrates that for turbulent flow, assuming conservation of angular momentum, kinetic energy of the eddy motion is transformed to that of mean zonal motion south of the westerly jet stream; north of the jet stream, kinetic energy of the mean zonal motion is dissipated by the eddy motion.

In the final section, author shows that analogous to the case for zonal flow, turbulence within the circulation of a typhoon either transfers its kinetic energy to the mean circular flow, or kinetic energy of the mean flow is transferred to the eddy motion, depending on rate at which work is done by eddy stress.

W. W. Berning, USA

2032. Yamashita, R., On "land and sea breezes," *J. meteor. Soc. Japan* (2) **31,** 5, 159–172, May 1953.

Paper makes slight extension of sea-breeze treatment by Jeffreys [*Proc. roy. Soc. Lond.* (*A*) **118,** 195–208, 1928], Defant [Compend. Meteor., Amer. Meteor. Soc., 655–672, 1951], and others. Most serious weaknesses are same as those of these previous approaches. The linearized hydrodynamic equations with eddy viscosity are used with the assumption of constant density except for thermal expansion, along with the equation of continuity and the equation of eddy heat conduction. Recent work by Stern ["Theory of the mean atmospheric perturbations produced by surface heating" submitted to *J. Meteor.*] shows that author's use of perturbation techniques in treating the sea breeze is probably not physically justifiable, due to assumption of constant eddy conductivity and viscosity. In fact, these parameters must actually vary by an order of magnitude in proceeding from sea to coast. Stern has shown, furthermore, that introduction of friction is not necessary to produce correct phase relations if some of the more important inertial terms are included, specifically, that one containing the undisturbed wind which author has left out of problem. Although author's results concerning phase of the sea breeze, its hodograph, and magnitudes agree rather well with observations, reviewer believes that the agreement is largely spurious and that the unrealisticness of the model by no means justifies the extreme ornateness of author's mathematics. The results are very little more realistic than those of Defant [op. cit.] with a cost of tremendous increase in complexity.

Serious but less vital deficiencies are complete lack of statement of assumptions, even the one that the equations have been linearized, and complete absence of documentation of references despite the fact that the treatments of Jeffreys [op. cit.] and Defant [op. cit.] have been only slightly extended in present work. Cited paper by Stern [op. cit.] contains a more general, physically realistic treatment of same problem with equally good or better agreement with observations and far simpler mathematics.

Joanne Starr Malkus, USA

2033. Austin, J. M., Arnold, G., Ainsworth, J. H., Courtney, F. E., and Lewis, W., Aspects of intensification and motion of wintertime 500-mb patterns, *Bull. Amer. meteor. Soc.* **34,** 9, 383–391, Nov. 1953.

2034. Arnason, G., A baroclinic model of the atmosphere applicable to the problem of numerical forecasting in three dimensions II, *Tellus* **5,** 3, 386–402, Aug. 1953.

A theory for the application to numerical forecasting of a three-parameter model of the troposphere is developed and then tested on one synoptic case. The model itself was described in the author's earlier paper [AMR **6,** Rev. 2963]. An essential feature of this model, beyond other models so far introduced, is that the static stability may vary arbitrarily in a horizontal direction and with time as well. This implies a thermal wind which may change direction with height, and it is shown that this nonparallelism of the isotherms in the vertical is important from the standpoint of thermodynamics. It is shown that the rotation of the thermal wind with height is closely connected with cyclogenesis and the deepening and filling of existing cyclones. The predicted tendencies by numerical computation fit fairly well with observed changes except for certain areas.

H. Arakawa, Japan

2035. Vuorela, L. A., A synoptic study of deformation fields, *Tellus* **5,** 3, 413–419, Aug. 1953.

Owing to lack of angular deformation along principal axes, extension of a prismatic fluid element along a principal axis depends on that coordinate only. Author thus studies intensity of quasi-horizontal dilatation of flow in 500-mb surface and its effect upon six-hourly deformation of grid squares used for evaluation of derivatives in numerical forecasting (method of barotropic pressure tendency). The limited data used fail to reveal relation between success-degree of forecast method and grid deformation rate.

Author gives evidence for the generally rather high values of dilatation being chiefly due to the basic assumption of his method (geostrophic wind approximation). Further indication for overestimation is absence of frontogenetic processes in cases where they are to be expected because of computed deformation; but qualitative arguments suggest the accompanying concentration of isotherms along axis of dilatation may be prevented by vertical motion effects.

F. A. Berson, Australia

2036. Fjørtoft, R., On the changes in the spectral distribution of kinetic energy for two-dimensional, nondivergent flow, *Tellus* **5,** 3, 225–230, Aug. 1953.

The two-dimensional, homogeneous, nondivergent, inviscid flow on the surface of a sphere conserves both total kinetic energy and the total vorticity squared. These integral constraints limit the energy transfer between different scales of motion. It is established that more energy will flow to larger scales than to smaller scales from an initially excited intermediate scale of motion. The introduction of viscosity does not alter this conclusion but rather emphasizes the persistence of large-scale and absence of small-scale components. The author concludes that observed flows can achieve smaller scales because they are three-

dimensional and hence do not conserve the square of the vorticity. Reviewer believes that a more important cause of small-scale motions is their production at the fluid boundaries.

W. V. R. Malkus, USA

2037. **Lorenz, E. N., The interaction between a mean flow and random disturbances,** *Tellus* **5,** 3, 238–250, Aug. 1953.

The main purpose of this paper is to expound the methods of statistical hydrodynamics and to recommend their use in flow problems in which the velocity fluctuations do not necessarily correspond to a fully developed turbulence. This exposition will perhaps be useful to meteorologists as an indication of a new view of dynamical problems, although the basic probability concepts are not described as clearly as they might be. As an illustration, the author analyzes the interaction between a mean flow and a superposed random disturbance (both two-dimensional) in a nonviscous fluid. Definite results are obtained only with the aid of very restrictive assumptions, and it is doubtful if the example will persuade anyone of the real utility of statistical methods in dynamical meteorology. The plain truth is that, once a disturbance is defined in probability only, it is exceedingly difficult to establish definite results, since usually there can exist one or two particular disturbances for which any given result is invalid. Nevertheless, it remains true that statistical hydrodynamics provides the proper framework for the description of many such problems.

G. K. Batchelor, England

2038. **Appleman, H., The cause and forecasting of ice fogs,** *Bull. Amer. meteor. Soc.* **34,** 9, 397–399, Nov. 1953.

Studies carried out in Alaska and Canada have shown that fog is a relatively rare phenomenon at temperatures between 0 and −30 F, with a minimum frequency between −20 and −30 F. At still lower temperatures, however, the frequency of fog increases rapidly. This effect is noted only in the immediate vicinity of inhabited areas, such as towns and airfields. The reason for the sudden increase in fog frequency at these temperatures, and the rarity of lack of fog at the higher temperatures, has not been heretofore explained. In a recent study on aircraft condensation trails, it was shown that, if the temperature is sufficiently low (between −20 and −40 F, depending on the relative humidity), the burning of hydrocarbon fuels, such as would occur in towns and at airfields, easily results in supersaturation of the air and a "surface contrail," or ice fog. At higher temperatures, on the other hand, combustion actually reduces the relative humidity of the atmosphere, hindering the formation of fog. In this paper, it is shown that low-temperature (ice) fogs form as a result of the combustion process, and curves are presented showing the temperature-dew-point relationship necessary for the formation of such fogs.

From author's summary

2039. **Sander, A., and Damköhler, G., Supersaturation in the spontaneous formation of nuclei in water vapor,** *NACA TM* 1368, 19 pp., Nov. 1953.

Translation from *Die Naturwissenschaften* **31,** 39/40, 460–465, Sept. 1943.

2040. **Godson, W. L., The evaluation of infra-red radiative fluxes due to atmospheric water vapour,** *Quart. J. roy. meteor Soc.* **79,** 341, 367–379, July 1953.

An empirical technique is developed for obtaining the flux transmission, over a narrow spectral interval, of an assembly of layers of varying pressure and temperature. The method is compared with the work of Elsasser and others. A principle advocated by Cowling is developed into a radiation-chart procedure in which the absorbing mass of each individual layer is corrected to a standard temperature and pressure. The coordinates of such a radiation chart are presented, but adequate experimental data for the construction of such a chart are not yet available.

R. J. Mindak, USA

2041. **Eckart, C., The generation of wind waves on a water surface,** *J. appl. Phys.* **24,** 12, 1485–1494, Dec. 1953.

This important paper is the first attempt at a statistical theory of wave generation. The storm is assumed to consist of a random distribution of pressure gusts, each characterized by its linear dimension, duration, and velocity. The paper consists of two parts. First, the wake from a single gust is derived by classical methods. The wake solution is then generalized to give account of generation by an ensemble of random gusts.

The theory succeeds in accounting for certain observed complexities of the sea surface, viz., the short-crestedness and the appearance of wave groups. However, it falls short of yielding observed wave heights by perhaps an order of magnitude. This may be because the assumed mechanism is inefficient, inasmuch as the pressure gusts are considered to be "uncoupled" to the already existing disturbance of the sea surface.

It is likely that modification in the assumed mechanism can lead to better agreement here, but the mathematical complexity (e.g., the evaluation of a sevenfold integral) will make itself uncomfortably felt. In all events, the method of statistical generalization (which is independent of the particular hypothesis of generation) has been shown to lead to a more realistic prediction of the sea surface than has previously been possible.

W. H. Munk, USA

2042. **Ursell, F., The long-wave paradox in the theory of gravity waves,** *Proc. Camb. phil. Soc.* **49,** part 4, 684–694, Oct. 1953.

The theory of long waves in shallow water under gravity employs two different approaches, which have given rise to a well-known paradox remarked by Stokes but hitherto not fully resolved. On the one hand, it was shown by Airy that, if the pressure at any point in the fluid is equal to the hydrostatic head due to the column of water above it, then no wave form can be propagated without change in shallow water of uniform depth; on the other hand, it was shown by Rayleigh's theory of the solitary wave that this conclusion may be incorrect. In the present paper an attempt is made to elucidate the paradox. Waves of small amplitude η_0 and large horizontal wave length λ (compared with the depth h of the water) are studied, and it is shown that Airy's conclusion is valid if $\eta_0\lambda^2/h^3$ is large, whereas the solitary wave has $\eta_0\lambda^2/h^3$ of order unity. It is also shown that the linearized theory of surface waves is valid only if η_0/λ and $\eta_0\lambda^2/h^3$ are both small. Some remarks are made on the generation of the solitary wave and on the breaking of waves on a shelving beach.

From author's summary by G. Birkhoff, USA

2043. **Ichiye, T., Some remarks on the non-linear theory of shallow water waves on a sloping beach,** *Oceanogr. Mag., Tokyo* **4,** 4, 159–166, Mar. 1953.

2044. **Bullen, K. E., An introduction to the theory of seismology, 2nd ed.,** New York, Cambridge Univ. Press, 1953, xvi + 296 pp. $6.50.

In this second edition the general pattern of the first edition has been preserved. However, an important improvement over the first edition is the inclusion of a list of references from which the reader will be able to trace details of most of the matter in the text and acquaint himself with recent trends in seismology. Several sections of the first edition have been largely rewritten

and a number of lesser alterations have been made. The main text of the second edition is approximately the same number of pages as the first edition. The second edition, however, has an additional 20 pages to cover the references mentioned previously.

R. L. Bisplinghoff, USA

2045. Nishimura, E., and Hosoyama, K., On tilting motion of ground observed before and after the occurrence of an earthquake, *Trans. Amer. geophys. Un.* **34,** 4, 597–599, Aug. 1953.

A large secular tilting motion of the ground was observed with a tiltmeter at a station in the epicentral region three months before the occurrence of a destructive earthquake. After examination of the reliability of observation, the secular ground tilt of this kind is considered to be intimately related to the earthquake occurrence and may be useful for prediction of a destructive earthquake and mitigation of disaster.

From authors' summary

2046. Simon, F. E., The melting of iron at high pressure, *Nature* **172,** 4382, 746–747, Oct. 1953.

Author has extrapolated recent experimental determinations of the melting point of metals at high pressure. He estimates that the iron core of the earth will be liquid if its temperature exceeds 4000 ± 300 K. Among the many geophysical implications of this conclusion, reviewer is particularly impressed with the possibility of magnetohydrodynamic convection. It is hoped that further study will not only substantiate the above estimate but also provide rough values of viscosity and thermal conductivity in the core.

W. V. R. Malkus, USA

2047. Zarembo, K. S., An estimate of displacements and deformations of underground gas conduits due to temperature, Nat. Sci. Found. tr-18, June 1953; *Doklady Akad. Nauk SSSR (N.S.)* **89,** 1, 53–56, Mar. 1953.

Marine Engineering Problems

2048. Telfer, E. V., Ship-model correlation and tank wall-effect, *N. E. Cst. Instn. Engrs. Ship. Trans.* **70,** part 1, 19–44, Nov. 1953.

At constant speed-length ratio, specific resistance increases linearly with blockage, the ratio of model, and net tank cross sections. This fact permits statistical analysis to isolate wall effect as a function of speed-length ratio for geometrically similar model series in tanks of different width. A consequence useful in commercial testing is that the same model should be tested in tanks of different width. The methods are applied to earlier tests of Comstock and Hancock and to tests of geometrically similar models and ship trials of the Lucy Ashton. An unexpected residual difference between model and ship is found to exist.

M. P. O'Brien, USA

2049. Rödström, R., Edstrand, H., and Bratt, H., The transverse stability and resistance of single step boats when planing, *Medd. SkeppsProvAnst., Göteborg* **25,** 42 pp., 1953.

The results obtained from the various forms seem to indicate generally that those forms which are satisfactory from a resistance point of view also have relatively good stabiltiy qualities. Of the values investigated in these experiments, the breadth of 4.66 m, the length of afterbody of 11.45 m, the height of step of 0.40 m, and the bottom angle of zero would appear from both aspects to be the best values of these dimensions for a boat of this type.

Since stability experiments, in particular, take rather a long time to carry out, the whole investigation had to be limited, not least for reasons of cost. Otherwise it might have been possible to extend the program to include a model with a further increased bottom angle. From seaworthiness considerations this could be regarded as a desirable modification.

From authors' summary

2050. Jasper, N. H., Study of the strains and motions of the USCGC Casco at sea, *David W. Taylor Mod. Basin Rep.* 781, 56 pp., May 1953.

This report presents and evaluates strain and motion data measured during the Spring of 1951 on the USCGC Casco while on weather duty in the North Atlantic. The appended material evaluates the performance of recently developed automatic strain- and motion-measuring apparatus. From author's summary

2051. Warholm, A. O., Some systematic experiments with models of coastal vessels (in Swedish), *Medd. SkeppsProvAnst., Göteborg* **24,** 95 pp., 1953.

2052. Krietemeijer, J. H., Optical marking-off system for plates and sections in shipbuilding, *Engineering* **176,** 4579, 570–572, Oct. 1953.

The particular optical system of mold lofting discussed was developed in Germany during World War II. The method utilizes lantern slides for projecting the lines on the steel plates. Details of the conventional and new mold-loft processes are given. In the author's shipyard, the optical method resulted in a 66% saving in time as well as economy of space. The process described has not made inroads in the United States, where variations of the photo-lofting process, used in the aircraft industry, are experimentally applied to mold-loft work. Both of these methods reduce the need for skilled labor and facilitate dissemination of template information within and among shipyards.

N. H. Jasper, USA

2053. Todd, F. H., Some further experiments on single-screw merchant ship forms—Series 60, *Soc. nav. Arch. mar. Engrs.*, Prepr. Ann. Meeting, Nov. 1953. Pap. no. 7, 59 pp.

Paper gives results of resistance tests carried out at David W. Taylor Model Basin with a new series of single-screw merchant-ship forms ranging in block coefficient from 0.60 to 0.80. New Series 60 is similar to Series 57 presented by Todd and Forest two years ago, but differs therefrom in having more U-shaped sections forward. As in the previous series, there was no bulb incorporated. Test results indicated Series 60 to be superior to Series 57 and to compare favorably with actual vessels of recent design. Because of favorable resistance characteristics, Series 60 has already been adopted as standard of reference in research on single-screw merchant-ship forms by a number of United States and foreign model basins. M. St. Denis, USA

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(Continued on inside back cover)